ARMY RESEARCH LABORATORY

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

ARL-TM-2012a **August 2012**

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Army Research Laboratory
Adelphi, MD 20783-1197

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14. ABSTRACT

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

All college undergraduate and graduate students receiving research appointments and conducting summer studies at ARL are automatically enrolled in the symposium program. As an integral part of their summer study, all students are required to write a paper on their work which summarizes their major activity and its end product.

The program is conducted on two separate competitive levels: undergraduate and graduate. The format of the paper in both levels is the same. However, the evaluation will take into consideration the difference in the academic level of the students.

All students submitted their research paper for directorate review. Directorate judging panels selected two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 9 August 2012.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 9 August 2012. At the symposium the students presented their papers to the ARL Director and an ARL Fellows panel.

This volume of the Summer Student Symposium Proceedings contains the abstracts for all papers prepared for the Summer Student Symposium Program.

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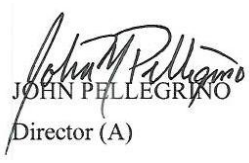
Director's Foreword

The U.S. Army Research Laboratory (ARL) mission is to "Provide innovative science, technology, and analyses to enable full spectrum operations." As the Army's corporate laboratory, we provide the technological underpinnings critical to providing capabilities required by our current and future Soldiers.

Our nation is projected to experience a shortage of scientists and engineers. ARL recognizes the criticality of intellectual capital in generating capabilities for the Army. As the Army's corporate laboratory, addressing the projected shortfall is a key responsibility for us. We have, therefore, identified the nation's next generation of scientists and engineers as a key community of interest and have generated a robust educational outreach program to strengthen and support them. We have achieved many successes with this community. We believe that the breadth and depth of our outreach programs will have a significant positive effect on the participants, facilitating their journey toward becoming this Nation's next generation of scientists and engineers.

A fundamental component of our outreach program is to provide students research experiences at ARL. During the summer of 2012, we supported research experiences at ARL for over 175 undergraduate and graduate students. Each of these students writes a paper describing the results of the work they performed while at ARL. All of the papers were of high quality, but only a few could be presented at our student symposium. The abstracts for all papers prepared this summer are contained in this volume of the proceedings and they indicate that there were many excellent research projects with outstanding results. It is unfortunate that there was not enough time for us to have all of the papers presented. We would have enjoyed hearing them all.

We are very pleased to have hosted this outstanding group of students for the summer. It is our hope that they will continue their pursuit of technical degrees and will someday assist us in providing critical technologies for our Soldiers.



JOHN PELLEGRINO
Director (A)

Introduction

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Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 9 August 2012. At the symposium, the students presented their papers to an audience of ARL scientists and engineers, including the ARL Director and an ARL Fellows panel.

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Arbitrary Unmanned Aerial Vehicle (UAV) Paths To Support Flight-Dynamics Model Using the U.S. Army Research Laboratory Power Line UAV Modeling and Simulation (ARL-PLUMS)

Adelman, Ross

The U.S. Army Research Laboratory (ARL) Power Line Unmanned Aerial Vehicle (UAV) Modeling and Simulation (ARL-PLUMS) is a powerful, interactive graphical user interface (GUI) developed in 2011 for calculating and visualizing the E- and H-fields around power lines. ARL-PLUMS is currently being upgraded to version 2.0 to support an ongoing Cooperative Research And Development Agreement (CRADA) with Optimal Ranging, Inc. The upgrades to ARL-PLUMS include the ability to specify an arbitrary, possibly nonlinear, flight path. This path will be used with a wire-avoidance algorithm and a flight-dynamics model as part of a real-time simulation to evaluate a new wire localization solver based on a Kalman filter. Other added features include the user is no longer limited to the number of lines in the model; the user can add groups of lines, such as “delta” or “wye” three-phase circuits; instead of specifying line currents directly, the user can attach virtual loads across lines and ARL-PLUMS will calculate the resulting currents; ARL-PLUMS renders the model geometry as model parameters are entered; and the user can select which signatures and cutting planes to render instead of them all being rendered by default. These upgrades will make it easier and faster to develop models and improve the quality of the results.

I wish to acknowledge the mentorship of David Hull.

Using Concentrated Electrolytes for Increased Oxidative Stability in High Voltage Li-Ion Batteries

Allen, Joshua

Common battery electrolytes are typically used at concentrations near 1M, where electrolyte conductivity is highest. However, higher concentrations of these electrolytes have largely been ignored, presumably due to their decreased conductivity or possible solvate crystallization. Although higher concentration electrolytes may not be useful in applications requiring fast discharge rates, increased oxidation stability can yield higher energy densities in low power applications. In this work, various electrolytes were tested via cyclic voltammetry to determine their oxidation stability as concentration increases. Preliminary results indicate that more concentrated electrolytes typically display increased oxidation stability. This phenomenon likely occurs because oxygen long-pair electrons are readily available for oxidation in uncoordinated solvent molecules (dilute solutions), while most solvent molecules are coordinated in concentrated solutions. Upon verifying an increase in oxidation stability by using concentrated electrolytes, multiple full-cells were tested with dilute or concentrated electrolytes to directly compare the results. The results are promising for high energy, low power battery applications, but still lack significant improvement to be realized in today's electronics.

I wish to acknowledge the mentorship of Richard Jow.

Fabrication and Characterization of Metal Insulator Metal (MIM) Diodes for Energy Harvesting Applications

Amani, Matin

The availability of portable energy sources for Soldiers is of strategic importance to the U.S. Army, as it seeks to reduce the total amount of stored energy (typically in the form of batteries) that must be transported into the theater. Solar cells are currently being used for this application; however, current single junction photovoltaic devices are only capable of 20% efficiency. Rectenna devices, on the other hand, have demonstrated efficiencies approaching 84% under microwave radiation, and have proven to be an effective technique for energy transfer; however, in order to use rectennas for energy harvesting, their operational frequency range must be extended to infrared or visible light. This research will focus on the development of high frequency metal insulator metal (MIM) diodes for this application. MIM diodes are ideally suited for this role since their operation is based on electron tunneling, which allows them to be operated at optical frequencies. A significant portion of this work will also focus on developing amorphous metals to use as atomically flat electrodes for MIM diodes, as well as investigating multilayer insulator (MIIM) diodes, which have both been shown to offer significantly improved device reproducibility and device performance.

I wish to acknowledge the mentorship of Matthew Chin.

Software and Hardware Development for the Eye Safe Laser Testbed

Amnuaysirikul, Arayut

The Eye Safer Laser Testbed is a state-of-the-art 1.2-kW, 1530-nm diode-pumped fiber laser facility under construction at the U.S. Army Research Laboratory (ARL). It consists of 40 fiber-coupled diode laser modules, high power multimode fiber combiners, 20 power supplies, and water chillers. LabView program and control electronics are designed, developed, and built for the testbed auto operation and monitoring. This presentation includes the design considerations and the software and hardware development. Initial results are presented. Laser interlock safety for the kilowatt power operation is also implemented in the emergency shutdown automation process.

I wish to acknowledge the mentorship of Jun Zhang.

Sensitivity Analysis and Sizing of a Fan-In-Wing Concept

Avera, Michael

This report investigates the preliminary design and sizing of a light duty Fan-In-Wing unmanned aerial vehicle (UAV) concept. The Fan-In-Wing concept employs a coaxial rotor system embedded within a flying wing aircraft to achieve vertical takeoff and hover while maintaining efficient cruise performance. During this investigation, we identified and analyzed areas of interest unique to this concept, such as scheduling the transition of power from fan thrust to jet thrust, the transition speed and wing sizing placing restrictions on the fan size, and sizing the engine for maximum efficiency during three unique flight regimes. A potential mission that encompassed the hover, cruise, and loiter flight modes was proposed, and a MATLAB code was developed to evaluate the aerodynamic performance of the fixed wing and rotorcraft properties. The code also graphically depicts the load sharing between the two lift systems. A sensitivity analysis was completed to identify the most important design parameters, and the Pareto efficient specifications were determined through multi-objective optimization software (JMP) to reach a final design. This design will be the basis for further iterative sizing procedures.

I wish to acknowledge the mentorship of Rajneesh K. Singh.

Acoustic Localization with Compensation for Wind

Au, Brandon

Accurate localization of targets is difficult, as we are often unaware of all the parameters involved. While visual cues may give a general location, the acoustic signal of the shot fired can be used to accurately locate the target. Using multiple microphone arrays, the location of an event can be identified fairly accurately by using the times of arrival and angles of arrival gathered by the arrays. However, many sources of signal interference add noise. While wind will have a negligible effect on sensors close to the source, sensors farther away will have greater effect. Increasing or decreasing the arrival of the acoustic signal by a few milliseconds could cause an error over 1 m. However, wind data is often not collected or changes rapidly, so blind wind estimation is calculated to best fit the given data. The goal of this project is to take the data collected by four microphone arrays and calculate the location of the event. Using that data, both location and wind can be estimated using various error minimizing methods. Further improvements will include better incorporation of poor data, better wind estimation methods, improved error minimizing methods, and better algorithms for data processing.

I wish to acknowledge the mentorship of Geoffrey Goldman.

Multi-scale Modeling and Experimental Efforts to Understand Shock Wave Propagation in Solids

Aydelotte, Brady

Shock propagation through solids has been of scientific and military interest since the 1940s. The shock properties of hundreds of compounds have been characterized, but it remains a practical impossibility to characterize all possible solids that are currently used. Multi-scale modeling offers a path to characterize both existing and notional materials by using physics-based models that can exchange information between disparate length and time scales to provide fundamental insight into material performance. An RDX crystal plasticity model, informed by molecular dynamic (MD) simulations, was developed and used to explore the elastic-plastic deformation of RDX at the single crystal level, and the influence of constitutive behavior on shock wave propagation and initiation. Models of WC+Epoxy and Al_2O_3+Epoxy (model systems) were developed to show the effect of mesoscale topology on shock wave propagation at the continuum scale. A capability for dynamic Raman spectroscopy is being created to probe high pressure states in situ during shock compression. It will allow for direct comparison with MD and continuum simulation data.

I wish to acknowledge the mentorship of Barrie Homan.

Mechanical Testing of Adhesive Material for Low Observable Tracer Round Application

Baeza, Jose A.

Conventional pyrotechnic tracer rounds provide a distinguishable burning trail for the shooter to follow and help to increase accuracy. However, the brightness of the conventional tracer also exposes the location of the shooter to the enemy and, as the tracer burns, mass changes lead to a trajectory dissimilar from non-tracer ammunition. Low Observable Tracer (LOT) rounds replace conventional pyrotechnic tracers with a non-combusting alternative that changes the tracer emission profile angle to reduce visibility by the enemy, but still maintains the trajectory of non-tracer rounds. There are many important considerations when evaluating this alternative technology: phosphor materials, energy sources, and the ability to find a binder material that will survive firing. Adhesive testing was performed through lap shear and butt joint tensile tests to determine the minimum force require for binders to survive live fire; testing also helped us to understand the effects that different binder types have on copper-based substrates. The binders studied included paints, silicon based adhesives, resins and epoxies cured under various conditions—e.g., different ultraviolet and temperature exposures. In all, 11 binder materials were studied, and a down selection process determined that six were viable for the LOT program.

I wish to acknowledge the mentorship of Andres Bujanda.

Characterization of PiezoMEMS Halteres for Flapping Wing Based Robotics Platforms

Bahnsen, Matthew

To maintain stability during flight, two-winged insects are equipped with small, dumbbell-shaped structures called halteres located behind each wing. The halteres act as 3-axis gyroscopes, collecting sensory input data about Coriolis (rotational) forces acting on them due to roll, pitch, and yaw, and sending the data to the insect's control system. The aim of the project is to better enable mm-scale air vehicle control by further studying the effects of Coriolis forces on microelectromechanical systems (MEMS) halteres. We fabricated MEMS halteres consisting of piezoelectric lead zirconate titanate (PZT) actuators and sensors. These PiezoMEMS halteres can resonate in the vertical, out-of-wafer direction, when time varying voltage is applied to the PZT thin film actuator. If during oscillation the haltere is spun on its axis, a Coriolis force will generate a lateral strain on PZT sensors along the sides of the haltere. These piezoelectric sensors on the haltere detect bending of the part due to the Coriolis forces and transmit an output voltage proportional to the amount of bending. The PiezoMEMS halteres will be diced and packaged on individual dual-in line package (DIP) packages and characterized using an angular rate table and custom built sensing electronics. These sensors will be evaluated for possible use in small scale flapping microflight based robotics platforms.

I wish to acknowledge the mentorship of Gabriel Smith.

Improved Signal Recovery Using Orthogonal Matching Pursuit Algorithms with Synchronous Impulse Reconstruction Radar

Bankole, Kalonji

This paper analyzes a series of algorithms for signal reconstruction using Orthogonal Matching Pursuit (OMP). Here, OMP was used as a greedy algorithm that took samples of prototype signals from a specified dictionary, and then merged those samples together to represent a real-world multidimensional sparse signal. The purpose of analyzing such an algorithm was to find which implementation would allow the Synchronous Impulse Reconstruction (SIRE) system to create a synthetic aperture radar (SAR) image in the least amount of time. The SIRE system's main purpose was mostly for detecting concealed threats in the battlefield, and the SAR image was used to present some form of visual interface to the user. As part of our investigation, we implemented each of these algorithms in different computer languages and compared the times they took to complete. After comparing the implemented algorithms, the one that was proved most efficient was ported directly to the graphical processing unit (GPU) to test for improvements.

I wish to acknowledge the mentorship of Kenneth Ranney.

Data Acquisition Implementation and Initial Testing of a Ducted Rotor Test Stand

Beals, Nathan E.

I designed a ducted rotor test stand that had the ability to measure the thrust and torque produced by the rotor and duct, independently, for a range of rotor pitches. It was anticipated that the presence of the test stand's central sting would affect the performance of the ducted rotor system. Therefore, the effect of the test stand was characterized by performing ducted rotor tests in the standard (rotor wake projected down toward the stand) and inverted (rotor/duct system flipped to project the wake upward, away from the stand) configurations. In order to perform these tests, the data acquisition system was refined and simplified from previous experiments. The results of the experiment were compared to computational simulations done previously, which predicted that the inverted ducted rotor system was a more accurate representation of the isolated system than the standard configuration. The goal of this research is, therefore, to determine whether the experimental results agree with the computational results so that the test stand can be used for further testing with confidence of accuracy. Conclusions will be made upon collection of experimental data.

I wish to acknowledge the mentorship of Ainsmar Brown.

Detection of Non-hazardous, Fluorescent Ricin-B Via an Immunoassay on Simulated Plastic Wings

Beatty, Glenn

As a schedule 1 controlled substance, ricin is one of the deadliest plant toxins in existence, and also one of the most easily accessible. This high-profile status has resulted in a surge of studies proposing improved methods of detection, primarily involving aqueous phase immunoassays. Successive methods report higher binding affinities and correspondingly lower detection limits, but little research has addressed the potential for new modes of implementation, extending beyond the aqueous phase. This study has examined the potential for detection along a solid/aerosol interface, offering the capability to monitor exposure to chemical/biological (CB) threats with a unique, wing-like packaging applicable to robotic vehicles. A solid plastic substrate treated with PolySorp^{TM}, simulating a plastic wing surface, was used to anchor the potential antibody, a glycosphingolipid dubbed monosialoganglioside (GM1). A monolayer of GM1 was introduced via direct adsorption followed by several rinsing steps, and successful deposition was verified using Raman spectroscopy. The substrate-antibody complex was then exposed to a known amount of fluorescently tagged, aerosolized ricin B (non-toxic analog) in a sealed, circulating environment. Fourier Transform spectroscopy quantified the amount of ricin B extracted, thereby gauging the effectiveness of the method and its theoretical application.

I wish to acknowledge the mentorship of Mark Bundy.

Designing a Wide Input, High Temperature, 1500-V Isolated, 2-W, DC/DC Converter with Adjustable Output Voltage

Bernstein, Matthew B.

Commercial DC/DC converters are plentiful, but very few can operate in high temperature settings. Most are only rated for 85 °C maximum operation, and those rated for higher temperatures have substantially decreased output power. The goal of this project was to create a 1500-V isolated DC/DC converter that could operate at an ambient temperature of 100 °C at greater than or equal to 2 W. A flyback topology with a pulse-width modulation (PWM) flyback control integrated circuit (IC) was selected. The chip receives feedback from the output and adjusts the duty cycle to control output voltage from fluctuating as input voltage changes. The resulting board was capable of sourcing a 2-W load at 105 °C ambient and operating beyond thermal equilibrium. The converter output voltage is adjustable from 12 to 20 V by setting two resistor values. The cost of the converter in volume is estimated to be cheaper than purchasing commercial converters. Although it is about three times the area and volume of a similarly rated, commercially available 85 °C converter, it is small enough to be used as a surface mount component and can serve as an improved alternative to commercial converters.

I wish to acknowledge the mentorship of Damian Urciuoli.

Scope: A Coping Model in Soar and the Improved Performance and Research Integration Tool (IMPRINT)

Best, Christopher

The Improved Performance and Research Integration Tool (IMPRINT) is used to define task networks and to simulate execution to assess the cognitive workload experienced during task performance. Soar is a cognitive architecture used to develop agents that use state information to select and apply actions in pursuit of a goal. I developed a simple model of coping behavior under high workload using the Soar system and an IMPRINT plugin to manage task component execution according to output from the model. During a simulation, the plugin provides current state information to the coping model, which responds with decisions stating which task components should be executed, delayed, interrupted, or ignored. The plugin implements these decisions in the simulation, automatically modifying task execution according to the model. I implemented an IMPRINT analysis of an unmanned aerial vehicle (UAV) control task used in an empirical study of load-shedding by UAV operators. The coping model reproduces two qualitative strategies used by the UAV operators in the study: omission of subtasks and complete neglect of a primary task.

I wish to acknowledge the mentorship of John F. Lockett.

Electrochemical Characterization of Monomerized Photosystem I of *Thermosynechococcus elongatus* and Osmium (II) bipyridine

Bigler, Melissa

Photosystem I (PSI) of *Thermosynechococcus elongatus* is a well-characterized trimeric protein complex that has been used for its ability to mediate translocation of electrons upon exposure to light. The protein is unique for its capabilities of efficiently converting solar energy into a utile chemical energy at high quantum efficiencies. However, electron transfer to PSI outside of its native environment remains exigent and inefficient. An osmium (II) bipyridine polymer is coupled with the protein complex to allow for the donation of electrons into the PSI's electron transport components and mediate the flow of a functional light-induced current. Electrochemical analysis of the native protein complex has been carried out with the employment of osmium (II) bipyridine preceding this analysis. Monomerized PSI is also a viable candidate for the production of current through photovoltaics, due to its potential to offer greater efficiency enabled by higher packing densities within the polymer matrix or unique electron transfer rate. The monomeric PSI is isolated by using a detergent and heat shock treatment. Electrochemical analysis procedures are carried out to characterize the monomerized PSI comparatively to the trimeric state.

I wish to acknowledge the mentorship of David Baker.

Designing Plasmids for Over-Expression in *Clostridium acetobutylicum*

Bowers, Maureen

The bacterium *Clostriduium acetobutylicum* uses different carbohydrates to ultimately produce acetone, butanol, and ethanol, which can be used as alternative energy sources. While the organism can metabolize either arabinose and xylose, both pentose sugars, for,use in its phosphoketolase pathway for glycolysis, *C. acetobutylicum* preferentially metabolizes arabinose over xylose. Given xylose is one of the predominant pentose sugars in plant biomass, we attempt to increase xylose use by cloning a phosphoketolase controlled by a xylose-inducible promoter into a plasmid for transformation into *C. acetobutylicum.* First, the promoter and gene are removed from the puc57 plasmid in which it was synthesized using restriction enzymes, then it is ligated into a multiple cloning site in the *C. acetobutylicum E. coli* shuttle plasmid pARL2A and transformed into *E. coli* for verification. After isolating the plasmid from *E. coli*, the promoter and gene insertion are confirmed by a restriction digest, gel electrophoresis, and sequencing. Plasmids from *E. coli* cannot be directly transformed into *C. acetobutylicum* because the bacteria will degrade DNA with a foreign methylation pattern. Therefore, the clone is transformed using a plasmid containing a *C. acetobutylicum* specific methyl transferase gene, allowing the plasmid to be methylated and recognized by *C. acetobutylicum* upon transformation. With this plasmid, *C. acetobutylicum* can more effieciently use xylose through induction of the phosphoketolase.

I wish to acknowledge the mentorship of Matthew Servinsky and Christian Sund.

Low-Power Evaluation of Avalanche Photodiodes (APD)

Brent, Jim

A network of gamma-radiation sensors composed of scintillators and avalanche photodiodes (APDs) has been developed to detect radiation signatures from large solar flares (leading to power-line transients) and isotopes (used in construction of radiological dispersive devices). A multi-pixel photon counter (MPPC) operates at 80 V, consuming ~10 mW. Reduced power consumption by the detector would allow the sensor to operate for longer periods of time in the field. APD characteristics are compared for operational power loading, spectral sensitivity, and cost. A new series of lower voltage APDs are comparable to the MPPC in performance, cost, and power. Preliminary results indicated that the new series of lower voltage APDs require 30% less power and a 42% reduction in cost.

I wish to acknowledge the mentorship of Marc Litz.

Wall Climbing Micro Ground Vehicle (MGV)

Bryant, Ian

The desire to remove Soldiers from high-risk situations like reconnaissance, and maintenance of buildings and infrastructure has spawned the idea of wall-climbing robots. Such robots use techniques ranging from magnets to gecko pads in order to climb vertical and inverted surfaces. The focus of this project is to run a comparison analysis of different vortex adhesion base plates, which would result in an improvement on the fundamental design of a robotic wall climber. This study includes initial experimentation into the use of inverted wing-inspired base plates to create adhesion forces on the robot. Experimentation on known technology (flat plate with full shroud) has the ability to generate low pressures between the wall and the robot. The use of this base plate in a robot design allowed the vehicle to hold roughly seven times its own weight—about 4.25 lb. A working platform was used as a control subject to compare the new base plate designs. Through extensive experimentation of the inverted wing base plates, I found that they create downward forces. Preliminary results have indicated that channeling this airflow to the impeller from the inlets will eliminate turbulent airflow that disrupts the vortex.

I wish to acknowledge the mentorship of Mark Bundy.

Engineering of Mixed Self Assembled Monolayers on Gold Surfaces for Optimal Biomolecule Absorption and Functionality

Bryner, Jordan

The ability to control the assembly of biomolecules on a surface without losing their stability and functionality is an increased need in bio-nanotechnology. Many commonly used surfaces, such as gold, are not optimal for biomolecular assembly because of their high hydrophobicity. Chemically modifying the surfaces of the biomolecules will increase their stability and improve their controllable surface assembly. Self-assembled monolayers (SAMs) are thin, single layers of molecules that self-organize on a surface. Single-molecule SAMs are popular in the literature, but mixed SAMs (i.e., those containing more than one type of molecule) may allow enhanced properties. In this work, mixed SAMs with varying ratios of 6-mercaptohexanol to 1-(11-mercaptoundecyl) imidazole are analyzed using ellipsometry, atomic force microscopy, and various electrochemical techniques. These methods will demonstrate that by varying the ratio of the alkanethiols—shown to form consistent and reproducible mononlayers on gold substrates—a surface specific to the needs of a target biomolecule can be engineered to optimize absorption and functionality.

I wish to acknowledge the mentorship of Amy Manocchi.

Integrating the CAST Global Positioning System (GPS) Signal Generator with the Gimbal Platform

Byers, Matthew

The Gimbaled platform system was designed to simulate real environments for unmanned aerial vehicles (UAVs) to evaluate autopilot hardware and software. The global positioning system (GPS) is an integral part in the control and operation of UAVs, providing absolute positioning data for outdoor navigation. A CAST Navigation 1000 GPS signal generator was used for the purpose of generating up to 12 artificial GPS signals. This device receives position and telemetry data via Ethernet communications and generates the appropriate signals. The X-Plane flight simulation software is integrated with the Gimbaled Platform System to compute vehicle dynamics and telemetry data necessary for the CAST GPS signal generator. I discuss the methods used to integrate this system into the X-Plane software, followed by a discussion of the underlying mathematics required to calculate vehicle position on earth and satellite positions in orbit.

I wish to acknowledge the mentorship of Justin Shumaker.

Labview® Control of a Novel Microtension System

Cadel, Daniel R.

Microtension offers a number of advantages over alternative tension experiments. The size scale allows for straightforward sample preparation protocols (milling of dogbone profile and polishing) and moderate loads to induce failure, all while maintaining bulk property domination. A system comprising a linear actuator stage with inline universal serial bus (USB) load cell and digital camera has been created on a standard optical table. The USB load cell provides real-time precision data at high sampling frequency without the need for additional data acquisition (DAQ) hardware. Labview® was used to integrate the linear actuator, load cell, and camera controls into a single Visual Instrument (Vl) to control all steps of the testing. Additional VIs were written for variations on typical tension tests, such as stress relaxation and jump-strain tests. Output data are passed through a Matlab® routine to yield image correlation-based stress strain curves.

I wish to acknowledge the mentorship of Brian Schuster.

Development of an Immersive Environment for Network Application Testing and Evaluation

Chacon, Samantha

Real-time mobile ad-hoc network (MANET) emulation allows network applications to execute unaltered in a realistic environment. Traditionally though, MANET scenarios are scripted and data collected without a human in the loop (HITL) to provide feedback in real time. This project places a HITL by using a commercial-off-the-shelf (COTS) first-person game to control radio positions in the MANET emulation. A number of technologies have been developed to bring this immersive environment to fruition, namely, the integration of real-world digital terrain information, tracking of user positions in the game environment, and real-time radio frequency (RF) propagation calculations that affect network and application performance. Multiple players within the game environment can communicate using voice over Internet protocol (VOIP) and video streaming applications executed through a MANET emulation. This integration provides an immersive environment for mission planning; technology assessment; and live, virtual, constructive experiments. I describe my effort to develop a realistic scenario using real-world terrain and Soldier-provided feedback. I also demonstrate the capability to track player positions in the external MANET emulation, thus providing the environment for application use and testing.

I wish to acknowledge the mentorship of Brian Henz.

Validation of the Extendable Mobile Ad-hoc Network Emulator (EMANE)

Chan, Aaron

The Extendable Mobile Ad-hoc Network Emulator (EMANE) is a software application designed to provide a versatile framework for real-time modeling of mobile network structures. EMANE's highly adaptable emulation environment supports the analysis of complex heterogeneous network configurations via controlled and repeatable virtual experiments, allowing the user to efficiently test new technologies and/or algorithms before implementing them into expensive real-world network systems. However, given its relatively recent introduction, there has not been extensive validation of EMANE's veracity in network emulation. This report seeks to present further validation by quantitatively comparing the results of various mobile network experiments conducted in the field to the results of the same experiments modeled within EMANE. It follows that the competence of EMANE as a network emulator varies inversely with the magnitude of the discrepancy between the experimental data yielded and their corresponding emulated data. Based on the empirical results of this study, we will assess the level of accuracy EMANE offers in its emulation of mobile network systems.

I wish to acknowledge the mentorship of Lisa Scott and Rommie Hardy.

Development of an Atmospheric Pressure Plasma Jet System for Metal Oxide Thin-film Deposition

Chang, Jian-Ming

An atmospheric pressure plasma jet system was designed and constructed in order to demonstrate the feasibility and effectiveness of oxide thin film deposition from metal organic precursors. Oxide films are used in many applications such as barrier coatings, sensors, and optical filters, among many others. Atmospheric pressure plasma deposition systems represent a relatively new area of thin film deposition on surfaces that offer several advantages over low pressure plasma systems. Thin films originating from metal organic precursors were deposited on silicon wafers using continuous and pulsed radio frequency (RF) power. Several electrode geometries were explored in order to obtain stable plasma conditions under RF excitation. Power, treatment time, and duty cycle were selected as processing parameters for deposition. The resulting samples were characterized using x-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), x-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR) to analyze film composition, morphology, and structure.

I wish to acknowledge the mentorship of Daphne Pappas.

Interfacing the Microsoft Kinect for Military Applications

Chavez, Michael

The Army has a vast amount of computers and workstations available at all times; however, these workstations cannot be considered "hands free." Many Soldiers are tethered to a ruggedized keyboard and trackball. These ruggedized input options for Army hardware are difficult to operate due to the required protective measures, i.e., gloves. We focus on using a low-powered Kinect camera system to detect the hand gestures from a Soldier to access programs such as the Ballistic Threat Field Calculator program. Since the Kinect camera system is a Windows operating system (OS) friendly device, it is difficult to use the correct drivers and application program interface (API) packages available for an Open Source OS, such as Linux. Currently, the API is being configured and developed to function in the Linux environment, whereas in a Windows OS, the driver and API development is not an issue. The goal is to use a free license OS, a universally supported programming language, and a low-powered camera system to create an easy-to-use, hands-free input method to make it easier for a Soldier in the field to operate a computing device.

I wish to acknowledge the mentorship of Song Park.

Variable Rail Voltage Control of a Brushless DC Motor

Chen, Yuan

A brushless DC (BLDC) motor achieves higher energy efficiency and endures less wear and tear than a traditional brushed DC motor due to the lack of friction between current coils and motor brushes; it, however, requires additional control logic, often implemented using a microcontroller, to perform motor commutation. Standard drive circuitry consists of a rail voltage applied to a three-phase inverter and a pulse width modulated (PWM) signal applied to MOSFET gates in accordance with the commutation pattern. Typically, motor speed control is achieved by varying the pulse width applied to the gates while maintaining a fixed rail voltage. We implemented a proportional-integral (PI) feedback system to control motor speed while varying rail voltage. Using this PI controller, we examined the relationship between steady-state power consumption and rail voltage for a fixed reference, as well as the effect of variable rail voltage on transient controller response and total transient power consumption.

I wish to acknowledge the mentorship of Will Nothwang.

Electrical Characterization of Transferred CVD Graphene Grown on Copper Foil

Chu, Albert

This work focuses on characterizing the electrical properties of chemical vapor deposition (CVD) graphene grown on copper foils. CVD graphene is transferred onto 3000 Å SiO_2/ n++Si substrates, and then Cr/Au metal contact Van der Pauw and long channel device structures are fabricated via photolithography and electron beam deposition. Electrical resistance and Dirac point measurements are taken in vacuum after 12 h of annealing at 373 K. Four-point probe resistance measurements were taken using the n++ Si substrate to sweep the back gate voltage bias. Resistance values increased as the back gate voltage approached the Dirac point. Dirac point values ranging from 36 V–73 V were observed for long channel structures. These results show that the Dirac point of graphene can be measured on very simple device structures, but the Dirac point values of these particular graphene devices are far from ideal.

I wish to acknowledge the mentorship of Barbara Nichols.

Electrochemical Characterization of Riboflavin-enhanced Reduction of Trinitrotoluene

Chu, Kevin

There is great interest in understanding trinitrotoluene (TNT) and dinitrotoluene (DNT) contamination, detection, and remediation in the environment due to TNT's negative health effects and security implications. Numerous publications have focused on detecting TNT in groundwater using multiple techniques, including electrochemistry. The main degradation pathway of nitrotoluenes in the environment is reduction, frequently with biological and/or photolytic assistance. Riboflavin has also been noted to aid in TNT remediation in soils and groundwater when exposed to light. This paper indicates that adding riboflavin to a TNT or DNT solution enhances redox currents in electrochemical experiments. Here AC voltammetry was performed and peak currents compared with and without riboflavin present. Results indicated that TNT, DNT, and riboflavin could be detected using AC voltammetry on modified gold electrodes and the addition of riboflavin affected the redox peaks of TNT and DNT. Poised potential experiments indicated that it is possible to enhance reduction of TNT in the presence of riboflavin and light. These results were dramatic enough to explain long-term enhancement of bioremediation in environments containing high levels of riboflavin and enhance the limit of detection in electrochemically based nitrotoluene sensing.

I wish to acknowledge the mentorship of James Sumner.

A Performance and Scalability Evaluation of the NS3 Real-time Distributed Scheduler

Contreras, Adriana

The ability to simulate high fidelity scalable networks in real time is of high interest to the Army because it allows realistic field scenarios to be tested without the cost of actually deploying networks and Soldiers into the field. The NS3 network simulator's MPI-based distributed scheduler has been further developed by the Mobile Network Modeling Institute (MNMI) at the U.S. Army Research Laboratory (ARL) into a MPI-based, real-time distributed scheduler. The real-time implementation of the scheduler on Department of Defense (DoD) high performance computing (HPC) platforms can potentially allow up to tens of thousands or more network nodes to be simulated. Performance measurements of this scheduler can provide insight on how well it can scale and perform such that realistic simulations can be provided to real-world exercises. This paper shares these measurements based on performance and scalability tests of the network scenarios using the real-time distributed scheduler in the NS3 network simulator on the supercomputing platforms at ARL.

I wish to acknowledge the mentorship of Kenneth Renard.

Quantum Tunneling Effect in Shape-controlled Gold Nanoparticles

Cramer, Hailey

At the nanoscale, the optical, electrical, and catalytic properties of a material depend on its size and shape. Therefore, synthesis of nanoparticles with controlled size and shape is important when applying them to biosensors, photovoltaics, and other optoelectronic devices. Whereas the effect of "size" on the properties of nanoparticles has been extensively studied in the past two decades, similar studies on the "shape" of nanoparticles have received little attention. The specific goals of this research are to synthesize nanoparticles with desired "shape" and investigate their structure-property relationships focusing on the quantum tunneling phenomenon. Recently, we successfully synthesized colloidal gold (Au), silver (Ag), and mixed Au-Ag nanoparticles using aqueous chemistry. The particles exhibited a mixture of shapes including spheres, rods, and prisms. In this work, we synthesize Au nanorods, nanospheres, and nanotriangles using a wet chemical seed-mediated growth method employing the surfactant cetyltrimethylammonium bromide (CTAB) as a growth-directing micellar template. Precise tuning of thermodynamic and kinetic parameters, and the addition of small concentrations of halide ions, enable us to obtain high yields of these shapes. Characterization of the particles is performed using tunneling electron microscopy, atomic force microscopy, ultraviolet-visible spectroscopy, and x-ray diffraction. Electron tunneling effects are investigated via scanning tunneling microscopy.

I wish to acknowledge the mentorship of Lily Giri.

Development of Assay for *Bacillus atrophaeus* var. *globigii* Environmental Detection

Dakos, Alex

A two-step polymerase chain reaction (PCR) system is developed for high-selectivity detection of hypersporulating *Bacillus atrophaeus* var. *globigii* (BG) strains in environmental samples. The Army has used hypersporulating BG strains as an anthrax simulant for 70 years. The goal is to provide Army researchers with an assay to expand their experimental capabilities to detect species that may be harmful to the Soldier. BG-specific primer sets are designed and tested against a panel of closely related species, including *Bacillus subtilis*, *Bacillus licheniformis*, *Bacillus amyloliquefaciens*, *Bacillus coagulans*, *Bacillus megaterium*, *Bacillus atrophaeus*, *Bacillus pumilis*, *Bacillus sphaeris*, and *Bacillus thuringiensis*. The region of interest is contained within the Spo0F gene, which directs sporulation. Because of the high homology of this gene, finding a suitable primer set is challenging. Primers are designed to generate amplicons larger than the targeted sequence of the second PCR step. Various primers are being tested, the difference among them being the size of the amplicon produced when they are used in a PCR. A primer set producing an amplicon of 137 base pairs is the most likely candidate for this assay since it's the most selective of BG over a background. This set produces an amplification difference of approximately three orders of magnitude, which matches the expected maximum for the first step of this assay.

I wish to acknowledge the mentorship of Dontcho Jelev and Dimitra Stratis-Cullum.

Direct Write of Micro-circuitry via the Development of Capillary Focusing Cold Spray Technology

DeHaven, Jennifer

Many techniques for the direct write of micro-circuitry have issues with adherence to the substrate; the impact velocities reached with cold spray techniques have the potential to address these issues. The cold spray process uses the energy stored in high pressure compressed gas (nitrogen or helium) to propel fine metal powders at high velocities (500–1500 m/s) onto a substrate. As the powder is propelled from the nozzle, it must reach a critical velocity before impacting the substrate to insure plastic deformation and bonding occur. Current cold spray processes are limited due to a lack of fidelity (minimum 2-mm line width). The process outlined within this paper shows that direct write of micro-circuitry is possible with the use of 100-micron capillary tubes, high pressure helium gas, and 1-5 micron diameter copper particles. The critical velocity of 500 m/s was reached and thin copper lines were successfully deposited onto an aluminum substrate. The deposited copper coating was analyzed using a scanning electron microscope and a stereoscope. The samples were then cross sectioned and polished before being analyzed by an inverted optical microscope; they were found to be 110 μm wide and 20 μm thick.

I wish to acknowledge the mentorship of Larry Holmes.

Increased Dielectric Breakdown Strength Via Permittivity Matching of Matrix Resin and Filler

De León, J. Eliseo

Polymer matrix composites (PMCs) are attractive for being lightweight, easily processed, and having tunable dielectric characteristics at relatively low cost. Emerging applications demanding high energy density devices, which replace existing bulky power supplies and allow for the miniaturization of electronic components, motivate our search for lightweight capacitive systems exhibiting high values of dielectric breakdown strength. Low viscosity monomer resins embedded with high permittivity (ε') ferroelectric filler materials offer a means by which we can produce PMC slurries tuned to the permittivity of the selected reinforcing materials, such as glass fiber. The work herein employs bisphenol E cyanate ester (BECy) monomer resin, cubic barium titanate nanoparticles, and E-glass microspheres. The Brugemann formula was employed to calculate the loading of $BaTi0_3$ nanopowder necessary to modify the ε' of the BECy monomer so as to match that of the E-glass. We aim to demonstrate that by matching the matrix resin permittivity to that of the reinforcing E-glass, our cured samples homogenized into the modified BECy/$BaTi0_3$ slurry will yield increased values of the breakdown voltage, and consequently of dielectric strength, of the PMC.

I wish to acknowledge the mentorship of Danny O'Brien.

Stairway Search for Multi-floor Autonomous Exploration

Delmerico, Jeffrey

Presently, robots are capable of autonomous exploration of single-floor structures, and many platforms are capable of autonomous stairway traversal. However, these systems have not been integrated for performing multi-floor mapping and exploration. The goal of my work is to provide the necessary functionality for bridging this gap. For a robot to confidently transition between levels of a building, it must robustly detect stairways in the environment, assess their traversability, and incorporate this knowledge into its path planning algorithm. I had previously developed a system for detecting stairways from depth imagery and fitting a simple parameterized model to many detections of the same stairway in order to measure its dimensions for assessment of the platform's ability to climb it. My work this summer focused on developing a search strategy for robustly locating any stairways in the environment. The robot exhaustively searches the space for stairs by observing all obstacles with its vision sensor. Upon a positive detection of a stairway, the robot samples from a distribution of possible poses for further observing the stairway and moves to these goal poses until the model of the stairway has converged or it has been confirmed as a false positive.

I wish to acknowledge the mentorship of Doug Summers-Stay.

Phased Array of Fiber Laser Collimators with Internal Phase-locking

Denkins, Jacob

Multi-channel, sparse-aperture fiber laser arrays with phase synchronization of channels offer a solution to overcome the challenges in constructing a compact, energy efficient, high optical power density laser system to irradiate small and remote destination area. Over this summer, I've fabricated, tested, and installed multiple elements of the system. I cut and shaped the piezoelectric actuator profiles that make up the high-speed precision bimorph fiber-positioners. For this technique, I have learned and trained with computer numerical control (CNC) machine, providing the micron accuracy cut of piezoelectric elements. I cleaved and installed the optic fibers into about 10 individual fiber-positioners and completely assembled about 15 micron sensitive aligning devices, which are used for initial channel alignments (applets). I tested the functionality of fully completed fiber-positioners. I installed the 19 lenses to the output of system. I started to investigate experimentally the power and interference quality of the periphery areas of Gaussian beam (beam-tails) intercepted with novel diffractive optic elements (DOE). These beam-tails provide the internal optical phase metric for recently developed new approach to phase synchronization of multiple fiber laser beams inside of array. This paper focuses on my contribution to the 19 channel fiber-integrated phased-locked array.

I wish to acknowledge the mentorship of Jony Liu.

Synthesis and Characterization of Boron-based Additives for Use in Novel Electrolyte Systems

Derricotte, Wallace

Essential to the chemistry of lithium-ion batteries is the formation of a solid electrolyte interface (SEI) on the surface of carbon-based anodes. Additives are used to alter the chemistry of the SEI and how it interacts with the lithium ion transport process. Boron- and silicon-based additives are of particular interest due to their respective reactivity and possibility to form soluble complexes in solution. The additives are synthesized from commercially available boron trichloride (BCl_3), silicon tetrachloride ($SiCl_4$), and perflouro-t-butanol. Upon lithiation, the perflouro-t-butyl alkoxide can participate in an addition reaction with BCl_3 and $SiCl_4$, adding at the chlorine sites on each compound. Upon synthesis, the compounds will undergo a series of chemical characterization and electrochemical characterization. Chemically they will be classified using boron/fluorine nuclear magnetic resonance (NMR), electrospray mass spectroscopy, and Fourier transform infrared (FTIR) spectroscopy. Electrochemically, the compounds will be tested as additives in battery cells using the industry standard electrolyte (ethylene carbonate [EC]: ethyl methyl carbonate [EMC]/ 30:70), a graphite anode, and copper-based cathode material. The batteries will undergo multiple cycles to determine how well they perform through extended use.

I wish to acknowledge the mentorship of Kang Xu of the U.S. Army Research Laboratory (ARL) and Arthur Von Cresce of the Morehouse College Chemistry Department, Atlanta, GA.

Methodologies for Coupling Computational Structural Mechanics Codes with Biodynamic and Damage Criteria Codes

Duran, Adam

Under-body blasts (UBB) are violent events that cause catastrophic damage to vehicles and, in most cases, injury or loss of life to occupants. Consequently, the Army and its constituents are investigating UBB to more accurately assess ground combat vehicle occupant survivability, and ultimately, develop damage mitigating technologies. To aid these efforts, the UBB event has been simulated on computing technologies to reduce the time and expense of designing and characterizing this dynamic event. This paper presents a comprehensive overview of the development of computational science methodologies and algorithms to couple computational structural mechanics codes with biodynamic and damage criteria codes, with the goal of better understanding the effects of UBB on ground vehicle occupants.

I wish to acknowledge the mentorship of John Vines.

Predicting Axonal Injury and Regeneration in the Brain Post Trauma: A pairing of Finite Element Methods with *in vivo* Imaging Techniques

Eidsmore, Ashley

Finite element (FE) models are widely used in the biomechanics community, yet fail to accurately correlate mechanical loading with tissue response and multi-scale injury mechanisms. State-of-the-art FE models incorporate imaging techniques such as diffusion tensor imaging (DTI) to reconstruct neuronal fiber bundles in the brain. The benefit of incorporating fibers is twofold: first, the fiber directions enhance material models by including anisotropy in constitutive models. Secondly, they provide insight on the structural connectivity of the brain, which is fundamental for cognitive functionality. Current methods at the U.S. Army Research Laboratory (ARL) correlate strain resolved in fiber direction and empirical cellular death models to predict damage. These models lack a validated relationship between strain and cellular injury. Additionally, they do not account for cellular repair. In this study, we investigated relationships between DTI-acquired measurements of pre- and post-blast injured mice and axonal strain. In order to reach this goal, an FE model and a novel process to recreate the structural network of the mouse were created. Using discovered relations, this platform will allow prediction of damage and recovery to be integrated into computational simulations and help validate the corresponding human model.

I wish to acknowledge the mentorship of Amy Dagro.

High-Temperature Reliability of Silicon Carbide Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs)

El, Mooro

The U.S. Army Research Laboratory (ARL) is investigating the performance and reliability of 4H-SiC depletion metal-oxide-semiconductor field-effect transistor (DMOSFET) devices for advanced power electronics applications. Oxide defects play an important role in determining the long-term reliability of these devices. An E′ center defect has been identified in SiC/SiO_2 devices via magnetic resonance measurement techniques. This particular defect is likely responsible for the threshold-voltage (V_T) instability generally observed in state-of-the-art SiC MOSFETs. The precursor for this oxide defect is an oxygen vacancy that forms during processing, resulting in a weak Si-Si bond. This bond may be broken—resulting in an active trap—not only by the radiation hole-trapping process, but also by the simultaneous application of a moderate oxide electric field at elevated temperature. Therefore, we have performed a variety of electrical measurements as a function of temperature and oxide field to investigate this high-temperature trap activation process. Our results indicate that the significant increase in V_T instability at elevated temperature is due, at least in part, to an increase in the number of active oxide traps caused by the high-temperature gate bias (HTGB) stressing of SiC power MOSFET devices.

I wish to acknowledge the mentorship of Ronald Green.

Synthetic Aperture Imaging with Multi-static Ground-penetrating Radar

Fenta, Kidanmariam

This research extends forward-looking multi-static imaging to include the ground penetration (GPEN) case, with a focus on frequency-domain approaches. We describe simulation and synthetic aperture radar (SAR) imaging software developed to investigate the effects of GPEN effects on multi-static SAR image formation. We describe both the simulation and image formation software, emphasizing the physics that affect the GPEN application. We present the results of experiments that illustrate the importance of incorporating these GPEN effects into the SAR image formation process.

I wish to acknowledge the mentorship of Kenneth Ranney.

Potentiometric Titration of Bio-based Furanic Polymers

Fountzoulas, George

The U.S. Department of Defense (DoD) has increased their use of polymers due to their lightweight nature and high performance. Unfortunately, traditional polymers are petroleum-derived, thus creating supply chain vulnerability. The DoD is looking to replace these petroleum-based polymers with less costly, more "eco-friendly" alternatives. This research seeks to develop furan-based polymers as bio-based alternatives to nylon, Nomex, Kevlar, and other high performance polymers. U.S. Army Research Laboratory (ARL) researchers have synthesized bio/furan-based polyamides. Unfortunately, characterizations of these polymers are difficult because of their insolubility in most solvents. This work examines the use of potentiometric titration to measure the concentration of amine groups to enable measurement of the number-average molecular weight of these polymers. The method was established by conducting a series of sample titrations using 1,6-hexamethylenediamine and 1,4-diaminobutane in either glacial acetic acid or in a dimethyl sulfoxide/glacial acetic acid mixture with perchloric acid. The titration curves of the sample titrations were sigmoidal. Titration of the bio-based polymers in glacial acetic acid or dimethylsulfoxide/glacial acetic acid solutions showed no sigmoid curves and the titration curves looked similar to the blank titration of glacial acetic acid. The polymer most likely had a low amine concentration, which is too hard to effectively measure.

I wish to acknowledge the mentorship of John La Scala.

Carbon Nano-material Thin Film Loudspeaker

Fullerton, Robert

A variety of carbon nano-material thin-film composites of different weight percentages were fabricated to characterize the resulting thermo-acoustic effects. I am interested in the possibility of overcoming, or even controlling, adverse aerodynamic phenomena over a range of platforms via sound pressure from carbon nanotubes (CNT)-thermo-acoustic films. Two types of polymers were used as the bulk of the composite material, Sylgard Q3-3600 and 186. The Q3-3600 has a much higher thermal conductivity than the 186, but they have similar heat capacities. Also, three different types of nano-material were used—single-walled, multi-walled carbon nanotubes, and graphene. The graphene sheets were fabricated by a dispersion method using polyvinylpyrrilidone (PVP) as a stabilizing polymer and were subsequently freeze-dried into a powder. A dry press technique was used to transfer the randomly oriented network of nano-material from cellulose filter paper directly onto the polymer or substrate, guaranteeing a percolating network. The fabricated CNT films were shown to have a range of resistances from 10–100 ohms and display excellent electrical conductance even at very low weight percents. The data indicates promising results for further testing with sinusoidal frequency currents in attempt to generate sound pressure with the film.

I wish to acknowledge the mentorship of Asha Hall.

Spectroscopy of ^{161}Yb with the Argonne Tandem Linear Accelerator System (ATLAS)/Gammasphere

Gaison, Jeremy

An experiment was performed at Argonne National Laboratory's Argonne Tandem Linear Accelerator System (ATLAS) accelerator using the Gammasphere array (~100 HPGe detectors), whose primary aim was to investigate the collective bands beyond band termination in ^{160}Yb via the ^{120}Sn(^{44}Ca, 4n) fusion-evaporation reaction. The high spin yield of the 4n channel was enhanced significantly by selecting a beam energy of 222 MeV, and a considerable amount of data of 3n and 5n channels were also obtained in the experiment. Here is presented the preliminary result of an initial spectroscopic analysis of ^{161}Yb, the product of the 3n channel. The RadWare (coincidence analysis) software package was used, and the possibility of revised level placements has been suggested by the analysis, in comparison with previous level schemes.

I wish to acknowledge the mentorship of James Carroll.

Effect of Acidity on Isobutanol Oxidation Over Rhodium-based Catalysts

Gamson, Adam

Isobutanol oxidation over zeolite-rhodium (Rh)-based catalysts was studied to investigate the role of acidity in its conversion mechanism. Three different Y zeolites (CBV720, CBV 760, and CBV780) with different Si/Al ratios (30, 60, and 80) were chosen for their varying acidities. It is characteristic in zeolites that lower Si/Al ratio corresponds to lower acidity, as confirmed by ammonia-temperature programmed desorption (TPD) experiments. Physisorption and chemisorption isotherms were taken for each zeolite-Rh powder to determine its physical characteristics. Based on the TPD and chemisorption data, the order of acidity was determined to be CBV720-Rh > CBV760-Rh > CBV780-Rh. Oxidation products of isobutanol are tunable–based; equivalence ratio (ϕ) can vary between three regimes—complete combustion, partial combustion, and dehydration. In this experiment, ϕ were tested between 0.176 and 6.34. In the partial oxidation regime, we observed that CBV780-Rh produced the most hydrogen with a selectivity of 61.4%, while CBV720-Rh and CBV760-Rh produced 48.6 and 42.4% hydrogen. However, it was difficult to correlate acidity to product formation due to other factors related to the zeolite cage structure, such as pore size and channel size.

I wish to acknowledge the mentorship of Ivan Lee.

One- and Two-dimensional Boron, Carbon, and Nitrogen Nanostructures

Gelinas, Benjamin

With a superior set of electronic, optical, and mechanical properties, hexagonal carbon structures, especially nanotubes and graphene, have emerged as potential candidates for future technologies. Graphene, a honeycomb lattice of hexagonal carbon, possesses zero bandgap (pristine structures) or an inconsistent nonzero electronic bandgap. For electronics and photonics applications, the presence of a bandgap is necessary for electronic switching or photoexcited phenomena. Recent research suggests that the bandgap of hexagonal carbon can be tuned using boron and nitrogen doping. Hexagonal boron nitride, an insulator, is a plausible doping agent for carbon because of its similar sp^2 hybridization, honeycomb hexagonal structure, and bonding properties. By creating a boron carbon nitride structure with a specific percentage of carbon, the bandgap of the structure can be engineered. The goal of this research is to synthesize and investigate the fundamental physical properties of one- and two-dimensional hexagonal structures composed of boron, nitrogen, and carbon atoms. The two-dimensional pristine and boron and nitrogen-doped hybrid graphene structures are synthesized by chemical vapor deposition method. The structure, morphology, electronic, and optical properties of the materials are characterized by a combination of scanning electron microscopy, transmission electron microscopy, atomic force microscopy, Raman spectroscopy, and ultraviolet (UV)-visible spectroscopy.

I wish to acknowledge the mentorship of Govind Mallick.

Development of Micro-tensile Experimental Methodologies at Different Strain Rates for Thin-metallic Films

Ghiorse, Steven

To study the effect of length scale on material response, mechanical loading experiments are required at smaller length scales. Micro-electromechanical systems (MEMS) materials and synthesized novel materials are often only available in small scales for characterization. Experimental methods are not readily available for conducting tensile experiments of micron-scale thin film specimens, especially for high loading rates. In this study, micro-sized uniaxial tensile experimental methods were developed to obtain the tensile response of thin films at different loading rates, including dynamic rates. Initially, micron-scale specimens were designed and unique specimen fabrication methods were developed. Experimental methods, including gripping and micro-digital image correlation (DIC) for micron-scale specimens, were developed, and tests were carried out using microscopic quantitative visualization, sub-micron speckling, a Bose-test system, and a unique Kolsky bar. Tensile experiments were conducted on electrodeposited nanostructured-Al-Mn 100 μm thin films under quasi-static, intermediate, and dynamicrates to obtain the tensile behavior at each loading rate. Aluminum 6061-T6 and Hadfield's Austenitic Manganese Steel (AMS) thin sheet specimens were also studied under same loading rates for comparison. The novel experimental procedures and stress-strain results for these materials are discussed in the report.

I wish to acknowledge the mentorship of Tusit Weerasooriya.

Investigation of 304 Stainless Steel Corrosion in a Carboxylic Acid-containing Organic Paint Stripper

Godbey, Griffin

A paint stripper containing benzyl alcohol and glycolic acid was selected to replace existing products that contain methylene chloride. Pitting corrosion of 304 stainless steel pipe fittings used for stripping baths that contain this alternative paint stripper has been reported. Some initial observations were made on the overall paint stripping operation, which may explain the corrosion of the construction materials used in the paint stripping operation. These include excessive heating of the alternative stripper and neglecting to use low carbon stainless steel in welded joints. Factors that can lead to the observed corrosion are ionic contamination of the stripping bath and poorly cast pipe elbow joints. The potential of the alternative paint stripper to cause corrosion of stainless steel is under investigation. Infrared spectroscopy was performed to distinguish differences between virgin and spent alternative stripper. An experiment designed to replicate the conditions that were observed in the production vats is underway. Additional experiments may include some chromatographic separation, nuclear magnetic resonance (NMR), thermogravimetric analysis (TGA), and control experiments with known pure materials on alloys used in the construction of the paint stripping baths.

I wish to acknowledge the mentorship of John Kelley and Joseph Labukas.

The Use of Representational State Transfer (REST) Web Services in Conjunction with Structured Query Language (SQL) Databases

Gollsneider, William

The Representational State Transfer (REST) is a networking architecture between client and server that is now the predominant Web service used on the World Wide Web. The key feature of a RESTful Web service is that it is stateless, such that no client data are stored on the server, and all communication from the client to the server is done through Uniform resource locators (URLs). While this architecture is primarily designed for use in retrieving Web pages, it can also be used in a closed setting for client to request a server to do work for them. This paper describes the use of RESTful Web services to request sensor event data from a structured query language (SQL) database stored on a server. These requests are in the form of a URL, which contains the parameters of the events to be selected from the database, such as sensor location, direction, type, and time of event.

I wish to acknowledge the mentorship of Robert Winkler.

Effects of Cognitive Workload on Ocular Scanning Patterns During Live-fire Shooting Trials

Gordon, Caleb

This study is a pilot effort scheduled for data collection on 23 July 2012. Ocular scanning patterns will be examined while under cognitive workload in a live-fire environment. Data will be generated using eye fixation tracking technology in conjunction with a secondary task (e.g., simple addition mathematics problems), while a subject is shooting from a reflexive firing position at a semicircular array of pneumatic gradated paper targets. Dependent measures for this study will include target engagement time and target hit percentage. We hypothesize that primary task focus will result in a high rate of eye movement and greater number of fixations in a diminutive area. Cognitive interference (a secondary task) is expected to lower the rate of optical fixations and should result in a larger viewing area of multiple horizontal planes.

I wish to acknowledge the mentorship of Frank Morelli.

Using Microwaves to Measure Spin Coherence of Rubidium Atoms During Transport

Grissom, Ian

Nearly all modern-day electronic devices rely on the use of charge as the information carrier. As the size of the transistors and microelectronics that drive these charge transports approaches atomic size, computational power per volume will reach a limit. However, the development of spintronic devices has the potential to improve a variety of computations and algorithms beyond the limitations of charge-based systems. Research has therefore been conducted to develop spin transport devices that are analogous or go beyond existing charge-based components. This research investigates the use of microwaves to measure spin coherence of ultra-cold Rubidium atoms during transport across a one-dimensional waveguide on the surface of an atom chip. It has been shown that ultra-cold rubidium atoms can be trapped and manipulated on the surface of the atom chip through the use of magnetic traps created by applying current through a chip wire and an external bias field. The application of microwaves at the resonant frequency of the hyperfine transition (6.8 GHz) should allow for coherent control of the atomic spin. The atoms will then be transported across the waveguide and the spin relaxation effects will be characterized.

I wish to acknowledge the mentorship of Patricia J. Lee.

Characterization of Single-layer and Multi-layer Textured Lead Zirconate Titanate (PZT) Thin Films

Grobicki, Alden

Piezoelectric materials allow for energy harvesting from charge produced by atomic strain. However, it is the reverse piezoelectric effect that makes the material so functional for microelectromechanical (MEMS) devices. By applying voltage to a piezoelectric material, it is possible to actuate the device, thereby creating motion. This research is focused first on the characterization of the electrical and mechanical response of piezoelectric lead zirconate titanate (PZT) films with a Zr/Ti ratio of 52/48 as a function of texture orientation (i.e., 111 versus 001). Cantilever arrays with beams of various lengths have been previously fabricated and will now be evaluated by laser Doppler vibrometry (LDV). In addition, (001) oriented PZT (52/48), multi-layer PZT actuators have been fabricated and will now be compared to their single layer counterparts by characterization of the electrical and mechanical properties of each device. The multiple layers produce increased stiffness and greater contact/restoring force, which can hopefully be used for more reliable devices capable of operating at a fraction of the voltage when compared to a single layer PZT-based device.

I wish to acknowledge the mentorship of Ron Polcawich.

Tribology of Micro-scale Ball Bearings: Towards High-Performance Microsystems

Hanrahan, Brendan

Microfabricated ball bearing systems provide a robust, low-friction, and low-wear platform for micro-electromechanical systems (MEMS). Silicon raceways are micromachined to accommodate stainless steel microballs using techniques derived from integrated circuit manufacturing. To date, the microfabricated bearings have been employed in linear and rotary actuators, micro-pumps, -motors and -turbines. Currently, there is not a comprehensive understanding of scaled-down ball bearings within silicon-based materials systems. The tribology of microfabricated bearings is the subject of this study, specifically addressing the scaling and increased influence of surface properties over volume properties. Friction, wear, lubrication, geometry, and diagnostic for rotary MEMS are addressed. This study provides the fundamental knowledge to engineer future high-performance power and energy-related microsystems.

I wish to acknowledge the mentorship of C. Mike Waits.

Growth and Transfer of Graphene for Device Fabrication

Hauri, Kevin

The unique properties of graphene enable the potential to develop improved field effect transistors with faster performance than the current technology. In order to synthesize atomic layer graphene for device fabrication, atmospheric pressure chemical vapor deposition (APCVD) of methane at a high temperature can be used on a variety of metal and foil substrates. Thin film sputtered nickel deposited onto silicon (Si)/silicon dioxide (SiO_2) wafers, nickel foils, and alloys containing copper and nickel mixture are catalyst substrates with the potential to synthesize device-quality graphene. Once graphene is synthesized on these substrates, it is transferred to a silicon oxide semiconductor before the device fabrication step. However, transferring without damaging the atomic layer graphene presents a number of challenges that will be explored. Additionally, after the transfer, removing the polymer without forming wrinkles, defects, or leaving residues on the graphene's surface that alter the original electrical properties has become a challenge. Processes will be developed for APCVD growth and transfer of graphene from Ni and Ni-Cu alloy catalyst substrates.

I wish to acknowledge the mentorship of Eugene Zakar.

Physical Comparison and Characterization of Quasar Remote Voltage Sensor (RVS) and Plessey Electric Potential Integrated Circuit (EPIC) Sensors

Heintzelman, Sean

Electric-field sensing has many defense applications including power line sensing, bullet detection, and biological sensing (electrocardiogram [ECG] and electroencephalogram [EEG]). The commercially available Plessey Electric Potential Integrated Circuit (EPIC) and Government limited Quasar remote voltage sensors (RVSs) measure the gradient of free-space electric potential to calculate electric field. One set of each of these sensors was characterized using the U.S. Army Research Laboratory's (ARL) highly accurate and uniform electric-field cage. An automated LABVIEW control system was used to control data collection for the experiment with measurements performed using applied electric-field strengths between 5 mV/m – 5 V/m over a frequency band of 10 Hz – 100 kHz to comprehensively analyze each sensor's frequency response. MATLAB analysis programs were used to derive typical transducer characteristics: these included field-referred noise spectral density, magnitude/ phase frequency response, and linearity. The measurements and analyses were repeated for each sensor pair using three unique distances between the gradiometer-pair to observe output gain. In addition to the transducer characterizations, a Keithley sourcemeter was employed to measure the power that each sensor consumed throughout the measurement so that a complete comparison of the sensor system can be made.

I wish to acknowledge the mentorship of Stephen Vinci.

Filament Wound Composite Helicopter Driveshaft

Henry, Todd

Filament wound composites have the potential to be used in a single-piece composite driveshaft, replacing current multiple-piece metallic driveshafts, which would reduce weight and maintenance downtime. The undulated fiber architecture related to the filament winding manufacturing technique produces unique challenges in the form of predicting fiber direction modulus and strength using traditional theories. Observing and developing a better understanding of the micromechanics of fiber micro-buckling in a filament wound composite tube in compression is necessary for using these composites in design. A $[\pm\theta/89/\pm\theta]$ tube laminate was devised for the express purpose of evaluating the compressive strength and elastic modulus of the unidirectional composite in the fiber direction—properties which are believed to be strongly affected by fiber undulations. Three-dimensional digital image correlation was used to measure in plane strains as well as radial displacements. When fiber-micro-buckling was directly observed, it was accompanied by a large concentration of negative axial strain, negative hoop strain, and a negative relative radius displacement. Experimental test results will be used in validation of a two-scale model used for predicting specimen modulus and strength for use in composite driveshaft optimization.

I wish to acknowledge the mentorship of Jaret Riddick.

Model Order Reduction of Neural Mass Models

Herzog, Alexander

Model order reduction (MOR) methods approximate the input-output relationship of high-dimensional dynamical systems using less complex systems. MOR works best with linear systems, but a method for reducing weakly nonlinear systems also exists. The established approaches of using linear algebraic methods for linear systems and Taylor series expansions spanning higher order derivatives for weakly nonlinear systems do not work well for strongly nonlinear systems. The trajectory piecewise linear (TPWL) method reduces the nonlinear dynamics by partitioning the state space into discrete regions and populating each region with a reduced linear model. TPWL simulates the full system's nonlinear trajectory using the weighted sum of nearby reduced models. Recently, neural mass models have grown in popularity as a means of simulating neural firing rates. Neural mass models represent the activation dynamics of small brain regions that can be connected to simulate large networks of brain regions. The dynamics of these models are chaotic, highly nonlinear, and strongly coupled, making for a challenging MOR problem. This paper details an implementation of TPWL for simple neural mass models at small time scales that yields reductions in simulation time and state space dimensionality. Outstanding challenges to MOR for neural mass models are also discussed.

I wish to acknowledge the mentorship of Manuel Vindiola.

BlueHoc: Distributed Computing over Bluetooth and Ad-hoc Networks on Android-based Mobile Devices

Hinojos, Gregorio

Mobile devices have become highly utilized recently; due to the high demand, advances in new mobile technology occur every day. Researchers are trying to use the numerous mobile devices readily available to solve parallelizable problems. In this paper, we introduce a system that allows distributed computing across mobile devices. This system enables Android-based mobile devices to form a Bluetooth ad-hoc network that can potentially behave as an high performance computing (HPC) cluster. The architecture of our system is master-slave based, where the master can be connected with up to seven slaves. In addition, the architecture also allows for slaves to connect with up to six other devices, enabling a limited ad-hoc network. Because the Android operating system deviates from the Linux kernel and does not have full support for GNU libraries, it does not allow us to port existing Linux applications or libraries. This increases the complexity of our system to be used for complex computations. The experimental results for our system are based on the computation of a Monte Carlo image-matching algorithm, which is used to exploit the parallelism of our system.

I wish to acknowledge the mentorship of David Bruno.

Characterization of Periodic and Random Metamaterials

Hodge, John

Metamaterials are artificial materials that have electromagnetic responses not generally found in nature. Metamaterials are usually characterized by their effective permittivity $\varepsilon_{eff}(\omega)$ and permeability $\mu_{eff}(\omega)$. If the material exhibits $\varepsilon_{eff}<0$ and $\mu_{eff}<0$, the material is referred to as a double-negative (DNG) metamaterial, or left-handed material. Composite structured materials formed from either periodic or random arrays of scattering elements have been shown to respond to electromagnetic radiation as continuous materials as long as the wavelength is much greater than both element dimension and lattice springs. In this study, each scattering element is a capacitively loaded loop (CLL), which can be tuned to a desired resonant frequency. The unusual properties exhibited by these negative-index metamaterials can be engineered for use in many antenna designs. Specific goals of this study are to learn measurement techniques for metamaterial characterization and perform computational simulations for metamaterials using different numerical techniques. An additional goal is to explore and analyze the differences between periodic and random arrangements of scattering elements. The project aim is to successfully calculate a negative index of refraction using measured S-parameters and radiation patterns for assembled metamaterials structures.

I wish to acknowledge the mentorship of Amir Zaghloul.

Constraint-based Hybrid Cellular Automaton (HCA) Topology Optimization for an Advanced Lightweight Blast Resistant Wedge-shaped Structure

Hofstetter, Jr. Dwight

Blast-resistant, wedge-shaped structures are designs that have significant rigidity. This study investigates further optimization to allow for maximum protection when constrained by additional weight. The Livermore Software Topology and Shape Computations (LS-TaSC) optimization software is a constraint-based hybrid cellular-automaton tool that can be used to design optimum solutions. This software takes into account size, shape, topology, and topometry (changing of element properties on an element-by-element basis). Optimization is achieved by designing for a uniform internal energy density while constraining responses such as plastic strains and von Mises stresses. This paper explores the utility of the enhanced LS-TaSC optimization software and its applications to U.S. Army Research Laboratory (ARL) researchers for creating optimal, blast-resistant, wedge-shaped structures for future and current vehicles.

I wish to acknowledge the mentorship of Dr. Rahul Gupta and Mr. Robert Bitting.

Through-thickness Tensile Experiments of Laminated Polymer Matrix Composites

Hoosier, Andrew

Through-thickness tension experiments were conducted to determine the inter-laminar strengths for a varying series of fiber reinforced polymer composites. The composite materials used in this study consist of two-dimensional (2-D) woven laminates, noted as X-Glass/DCPD, E-Glass/DCPD; and a hybrid, three-dimensional (3-D) woven laminate. The hybrid laminate (total thickness of ~15 mm) comprised two outer layers of carbon plies (4 mm thick) encasing the S2-glass section at the center. The entire laminate is stitched together along the z-axis by Kevlar fiber tows. As additional details, the X-glass is designated as a new class of E-glass by PPG Industries. Along with the X-glass and E-glass laminates, these composite panels incurred residual loss in strengths due to prior V50 ballistic impact experiments. Thus, the results reported for the tensile properties are the measure of the residual strength for both X-glass and E-glass. However, there were no "as-received" panels to establish any baseline at the time of this effort. The test methodology used conforms closely to American Society for Testing and Materials (ASTM) D7291 and involved the bonding of aluminum gripping tabs to the top and bottom surfaces of the specimens with Armstrong A-2 Epoxy Resin Adhesive. The experimental procedures and results of the strengths and stiffness for each material are documented in the report.

I wish to acknowledge the mentorship of Paul Moy.

Characterizing the Performance of a Robot-mounted Global Positioning System (GPS) Receiver

Hoppel, Mark

The goal of this project is to determine the accuracy of a robot-mounted global positioning system (GPS) sensor. In order to qualitatively understand the impact of environmental stimuli—e.g., power lines, buildings, weather, or the time of day—on the accuracy of the sensor, tests will be run at several different locations over three days. Variables taken into account when choosing testing positions are: nearness to buildings, nearness to telephone wires, and whether or not the robot is near multiple buildings. In addition to determining the effect of the aforementioned stimuli, tests will also be made to determine potential electro-magnetic interference from the Kinect system on the GPS reading. In order to do this, the robot will take two readings from the same location—one with the Kinect on, and one with the Kinect off. After data has been collected, it will be processed in order to determine the average position, the range of the positions, and the deviance of the positions gathered by the GPS. When all of the data has been processed, the results will be compared in order to understand the performance of the GPS under different conditions.

I wish to acknowledge the mentorship of Mary Anne Fields.

Simulation of Stimulated Brillouin Scattering within a Ytterbium Fiber Amplifier

Huang, Shuochen

The simulation built in Matlab models three partial differential equations describing the behavior of the laser wave, the Stokes wave, and the acoustic wave with respect to time and space and two ordinary differential equations describing the behavior of the pump wave with respect to space and fractional inversion of ytterbium with respect to time. It was determined that using Heun's method, an improvement over Euler's method, causes error scaling inverse quadratically with the number of iterations while requiring less than 50% additional computation time. In addition, the evaluation of the three partial differential equations along their lines of characteristics rather than the time axis, as was explored previously in another simulation, seems to cut down computation time by approximately 50%.

I wish to acknowledge the mentorship of Jeffrey White.

Brillouin Spectroscopy in Large Mode Area and Single Mode Optical Fibers

Jacobs, James

Fiber lasers have been proposed as a method to protect Soldiers from rockets, artillery shells, mortars, and other forms of enemy armaments, because their small form factor, light weight, and high wall plug efficiency make them very attractive. One consistent problem lies in stimulated Brillouin scattering (SBS) in fiber amplifiers and delivery fiber, which causes lower power output due to backwards scattering on guided acoustic modes within the fiber. The onset of SBS scales with input power and fiber length and for laser power beyond threshold a large fraction of the forward propagating power can be scattered backwards. By measuring the backward scattered homogeneous and inhomogeneous SBS bandwidth, we can more accurately model and characterize Brillouin scattering in fibers for future experiments and models. Experiments were carried out to determine these important characteristics.

I wish to acknowledge the mentorship of Jeffrey White.

Drowsiness Detection Systems Development

Jordan, Kesshi

Both the public sector and the military are working to develop drowsiness detection systems, as driver fatigue is a significant contributor to motor vehicle accidents. Individually, electroencephalography (EEG) and eye-tracking measures are tenuous indicators of driver impairment. This project proposes to fuse multi-sensory data to achieve a higher accuracy of drowsiness level assessment and driver performance prediction than can these measures independently. The project hypothesis is that multiple eye-tracking measures, specifically pupil diameter and gaze distribution, can be used to accurately predict driver performance in a simulation environment. This project is part of a collaborative effort in which other algorithms are being developed to identify alpha bursts, an EEG indicator of drowsiness, and to correlate alpha-burst occurrence with driving performance impairment. Upon their completion, these projects will be synthesized into an algorithm that predicts driver performance using both EEG alpha-burst detection and the aforementioned eye-tracking measures.

I wish to acknowledge the mentorship of Will Nothwang.

Engineered Bacteriorhodopsin for Biosening and Solar Cell Applications

Joyner, Katherine

The bacteriorhodopsin (bR) protein is a proton pump naturally found in patches of the purple membrane (PM) of *Halobacterium salinarum*. Incorporation of bR with inorganic materials has encouraged the use of this protein in novel nano-bio applications. Using bR in these applications requires control of the endogenous lipid content for maximum systems efficiency. Here we demonstrate the systematic size control of bR by detergent removal of the endogenous lipids. The detergent used in this process was Octyl-β-d-glucopyranoside (OG), at varying protein exposure times and detergent to protein ratios. Using dynamic light scattering and ultraviolet (UV)-visible (Vis) spectroscopy, the bR diameter and activity were monitored throughout the delipidation process. Initial studies demonstrated that after 24 h of protein exposure to OG we were able to engineer a 140-nm-diameter fully active bR protein. Upon the detergent removal, the size engineered bR will be conjugated via a 1-ethyl-3-3-dimethylaminopropyl carbodiimide (EDC) peptide linkage to titanium oxide (TiO_2) nano rods and served as a sensitizer in a dye-sensitized solar cell. This engineering of bR for incorporation onto TiO_2 nanotube materials represents the systematic size control of bR for enhanced nano-bio applications.

I wish to acknowledge the mentorship of Mark Griep.

Assessing the Applicability of the Digital Image Correlation (DIC) Technique in Tensile Testing of Fibrous Composites

Justusson, Brian

Advanced aluminum alloys and fiber reinforced composites (FRCs) are desirable structural materials for making military vehicles more deployable and agile. Before these novel materials can be implemented on vehicles in the field, however, extensive mechanical characterization and numerical simulation work is needed. Digital image correlation (DIC) is a photogrammetric technique widely used in both static and dynamic mechanical testing to determine material properties. The technique relies on a series of digital images taken during mechanical testing to calculate displacement within a local field. This work aims to understand how the DIC method could be used to determine strains by examining the difference between two engineering strain measures. The first method involves a traditional random speckle pattern, while the second involves two points at a known distance. The results indicate that there is minimal difference between the two strain measures until final failure for a typical thin composite specimen using a single camera. However, for thick composite panels, this study has established that a two-camera DIC system is required to quantify the initial bending to ensure it is within the allowable limits established by the ASTM D3039 standard. This would allow for more accurate reporting of mechanical properties.

I wish to acknowledge the mentorship of Chian-Fong Yen.

Optical Cross Sections of Erbium Ions in Yttrium Aluminum Garnet and Scandium Oxide

Kacik, Natalie

The U.S. Army has a large program dedicated to the creation of power-scalable solid-state lasers. Essential to the design of these lasers is the ability to predictably select materials that are eye safe and optimal for lasing. The goal of our research is to collect and fit the peak cross sections of erbium (Er^{3+}): yttrium aluminum garnet (YAG) and Er: scandium oxide ($Sc_2O_{3)}$. Ultimately, the fits will be used by a colleague to develop theory that can explain why one type of crystal material is better for lasing than another.

I wish to acknowledge the mentorship of Larry Merkle.

Modifying a Cellular Sensor System Against Sugar-based Inhibition

Kadry, Nadia

In quorum sensing, bacteria coordinate population-based behaviors using small signaling molecules called autoinducers. One autoinducer, AI-2, may be a universal signal among species. Extending the University of Maryland's work on a modified strain of *E. coli* that fluoresces in response to exogenous AI-2, our lab has modified the sensor system, PhaseIΔFG, to fluoresce brighter and for greater lengths of time. PhaseIΔFG is regulated by the cAMP Receptor Protein (CRP), which complexes with cAMP in response to sugar. In the presense of sugar, PhaseIΔFG shuts down because the cAMP concentration is low and CRP-cAMP complexes are not formed. To eliminate this limitation, we attempted to introduce a mutated form of the CRP gene (a gain-of-function variant) to allow transcription of regulated genes to continue regardless of cAMP concentration. We amplified a template of the mutant using a polymerase chain reaction (PCR) and ligated the PCR product into one of two vectors (PET200/pCR2.1). After transforming them into Invitrogen One Shot® TOP10 cells, the modified plasmids were extracted and digested to isolate the CRP insert. The gel-purified product will be ligated into pBad28ΔAmp an expression vector compatible with PhaseIΔFG. To complete the modification, pBad28ΔAmpCRP will be transformed into PhaseIΔFG cells. Successful expression of a functional CRP gain-of-function mutant will result in a sensor that is uninhibited by its media.

I wish to acknowledge the mentorship of Matthew Servinsky.

Hovercraft- Design and Construction Analysis

Kaste, Brian

Improvised explosive devices (IEDs) can be detonated by a significant pressure change. Small, unmanned hovercrafts are ideal for completing reconnaissance missions across potential or known minefields because hovercrafts exert low pressure on the ground. Also, mesoscale hovercrafts will generate less noise and heat through their motors and power supply than a large hovercraft designed for higher power consumptions, making them less likely to be detected by visual, audial, and thermal scans. A previous design build was modified for updated objectives and specifications. A simple deck design simplified the establishment of component placement. An air cushion design was selected instead of a skirt design to achieve an acceptable hover height and stability combination. Calculations were made for the required levitation pressure, volumetric flow rates, thrust, and power levels under ideal conditions and performance. Measurements of the hovercraft under actual conditions determined these results. These deviations show that the hovercraft was approximately 75% efficient.

I wish to acknowledge the mentorship of Robert Haynes.

Self-consistent Modeling of Entangled Network Chains and Linear Solvent Chains in a Single-chain Mean-field Slip-link Model

Katzarova, Maria

Cross-linked polymer networks swollen with polymeric solvent have shown adaptive mechanical response. This frequency dependent response makes these gels desirable for applications such as tissue simulants for ballistic testing. This experimental observation is qualitatively modeled with the discrete slip-link model (DSM). Two applications of the DSM are used: first, an ideal entangled network (IEN) is modeled. This network is stoichiometrically cross-linked and no dangling ends, soluble sub-structures, or solvent are present. Secondly, the DSM is applied to these ideal entangled networks with solvent chains. This application is a coupling of two architectures: (1) entangled network chains (ENC) and (2) entangled solvent chains (ESC). The experimental system modeled is a stoichiometrically cross-linked polydimethylsiloxane (PDMS) network in the presence of high-molecular weight PDMS linear solvent. Network relaxation behavior is predicted.

I wish to acknowledge the mentorship of Jan Andzelm.

Processing Boron Carbide by Spark-plasma Sintering

Kecskes, Ian

The Army has an interest in improving boron carbide, which is already used as an armor material. Recently, the U.S. Army Research Laboratory (ARL) has begun a modeling program to simulate an intergranular film that would wet the grains of boron carbide. Simultaneously, experimental research has begun to develop such a glassy intergranular phase that would wet the grain boundaries. As a first step towards that objective, the goal of this project is to characterize the different properties of boron carbide with various additives. Boron carbide powder is blended with these additives and then densified using the spark plasma sintering method (SPS). Afterwards, the consolidated puck is subjected to various methods of characterization to evaluate its physical properties and microstructure. Upon completion of the evaluation, analysis is conducted on each composite for the presence of the glassy intergranular film. The results of this effort are then discussed.

I wish to acknowledge the mentorship of Jerry C. LaSalvia.

Consolidation of Aluminum Magnesium Boride ($AlMgB_{14}$) by Pulsed Electric Current Sintering (PECS) Technique

Kedir, Nesredin

The ternary ceramic alloy $AlMgB_{14}$ retains high hardness values and low density, making it a viable candidate for armor applications. $AlMgB_{14}$ has an orthorhombic unit cell and the signature B_{12} icosahedra found in many borides. Hot pressing (HP) is commonly used to produce bulk samples of this material, starting with powder mixtures. Low heating rates and indirect heating makes HP inefficient in terms of processing rates and cost. Hence, this study focuses on acquiring optimum processing parameters, resulting in single phase $AlMgB_{14}$ samples with low porosity and ideal mechanical properties using pulsed electric current sintering (PECS) technique. Al-13.3%Mg-74.7%B (wt%) elemental powder components were mixed in an acoustic mixer and sintered, then characterized by optical and scanning electron microscopy (SEM). Density of the consolidated samples was measured by the Archimedes method and phase characterization was carried out by X-ray diffraction (XRD). Microstructures of the samples were examined by SEM, and elemental composition was determined by energy dispersive spectroscopy. Vickers hardness measurements were performed. Furthermore, reactivity of the elemental powders was examined by differential scanning calorimetery to further optimize the PECS processing parameters.

I wish to acknowledge the mentorship of Kyu Cho.

Assessment of the Screening Obscuration Module Technology

Kelly, Juan

The Screening Obscuration Module (SOM) produces a cloud of obscurants in the visual spectrum. The SOM was developed to protect Soldiers from enemy observation and fire by providing them with the capability to conceal themselves and their equipment in open terrain. Two vendors, each with different conceptual designs, created SOM prototypes. The prototypes were assessed in mounted and dismounted configurations during developmental tests, and early user evaluations to obtain operational feedback. Post-test questionnaires, informal interviews, and observation/comment cards were used to collect feedback. Among the data collected during these test events were demographics, anthropometric measurements, and New Equipment Training feedback. The data were used to determine how well the SOM prototypes met key performance requirements, and to identify design changes required to improve the usability, survivability, reliability, and effectiveness of the system. This report focuses on the Technological Development Phase Testing conducted to assess the ability of the two vendors' SOM designs to operate in a mounted and dismounted environment.

I wish to acknowledge the mentorship of Lamar Garrett.

Understand the Fracture Response of Aluminum Oxynitride (AION) Single Crystal Through the Mechanical Testing of Spinel

Khoma, Petro

Aluminum oxynitride (AlON) is a transparent ceramic that can withstand severe impacts at high rates. These properties make it of great interest as a transparent armor material. Thus, understanding the fracture response and crack propagation is a priority. Testing the fracture response of AlON is feasible but difficult due to the lack of large single crystals. Fortunately, AlON has a spinel structure identical to that of readily available magnesium aluminate ($MgAl_2O_4$), referred to as spinel. Performing instrumented nanoindentation testing on single crystal spinel samples with orientations, <100>, <110>, and <111>, then examining the resulting fracture response and crack propagation provides insight into the fracture response of AlON single crystals. Indents at various depths, using both a Berkovich and spherical indenter tip on each orientation, allows us to collect the hardness, elastic modulus, and natural crack propagation. Examination of each individual indent using scanning electron microscopy shows the population of cracks and corresponding crack lengths for each orientation. The resulting data suggest that crack length directly correlates to indentation depth and the orientation of the crystal determines the crack symmetry around the residual indent.

I wish to acknowledge the mentorship of Brian Schuster.

Measurement of Group Velocity Dispersion Using White Light Interferometry

King, Alex

Group velocity dispersion, caused by the different wavelength components of the pulse traveling at different velocities, temporally broadens a femtosecond laser pulse. Additional dispersion can be added when short laser pulses interact with optical components. In an applied spectroscopy laboratory setting, white light interferometry can be used to measure the group velocity delay imparted to the ultrafast laser pulse by different broadband dielectric mirrors when compared to metal-coated mirrors. The wavelength-dependent group delay and chromatic dispersion of the broadband dielectric mirrors will be determined by using a Michelson interferometer. A broadband dielectric mirror will be placed in one arm of the interferometer, while the other arm will contain a reference mirror with a metallic coating. When the light from both arms is temporally overlapped, interference fringes will appear. The collected interference data will be analyzed via an algorithm, allowing for the determination of the group delay. The collected group of delay information will allow for determination of whether the broadband dielectric mirrors can be used to maintain short laser pulse duration. If the group delay data conflicts with the manufacturer's group delay data, the optic cannot be used and must be replaced.

I wish to acknowledge the mentorship of Ellen Holthoff and John Brady.

A Novel Corrosion Monitoring Technique Incorporating Lipid Layers on Metal Substrates

Kinlein, Scott

The purpose of this research is to explore lipid layers as a potential biosensor for corrosion. We hypothesized that applying a lipid layer to metals will allow for corrosion monitoring by measuring lipid degradation as a response to oxidation of the metal substrate. The experiment was designed by the P&D team and myself to test this lipid layer monitoring technique on aerospace-grade aluminum alloy 6061 (Al 6061). The experimental design involves application of the phospholipid 1,2-dipalmitoyl-*sn*-glycero-3-phosphocholine (DPPC) to small Al 6061 coupons (5 x 5 x 0.15 cm), followed by corrosion acceleration in a salt fog chamber. Data acquisition is accomplished in the form of impedance analysis by the Keithley 4200-SCS Semiconductor Characterization System, and in the form of physical degradation analysis by an Atomic Force Microscope. We hope to find a quantitative correlation between lipid layer degradation and aluminum corrosion that reveals this process as a new method for corrosion monitoring. With further research, this method could prove to be a cost effective, nondestructive platform for a broad range of materials analysis techniques.

I wish to acknowledge the mentorship of Anindya Ghoshal.

Modeling Genetic Regulatory Networks Using First-order Probabilistic Logic

Kishore, Nand

New technologies such as microarrays and flow cytometry have led to the availability of large amounts of biological data. There is a need to model biological systems to aid in medication and drug delivery. Genetic regulatory networks (GRNs) are networks that model signal transduction pathways. Specifically, they represent the activation and deactivation of genes as their corresponding proteins directly or indirectly interact with one another. GRNs can be modeled using statistical and logical techniques, more precisely using Bayesian networks. Bayesian networks are directed acyclic graphs (DAGs) in which nodes represent random variables and edges represent conditional dependencies. The learning problem is to determine the structure and the parameters of Bayesian networks to model GRNs from real data. PRISM, a probabilistic framework based on B-prolog was used to program the Bayesian networks. A hill-climbing algorithm using the free energy as a scoring function was used. Furthermore, instead of convention statistical techniques, which rely on point estimates, the method of Variational Bayes was used to obtain an approximation to the marginal likelihood, or the free energy, and a set of optimal parameters. The learning algorithm is tested on a well-established "Raf" pathway.

I wish to acknowledge the mentorship of Radhakrishnan Balu.

Wave Guiding in Periodic Auxetic Lattices

Kittur, Chandan

I studied the acoustic wave propagation in meta-materials with an auxetic lattice topology. Continuous periodic cell structures smaller than a desired wavelength have been shown to attenuate and guide waves. The ranges of frequencies where the acoustic waves will be attenuated are known as band-gaps, which is optimal region when designing the structure. This property of meta-materials can be used to make lightweight structures that redirect and guide energy away from sensitive areas. To experimentally validate the wave-guiding property of meta-materials, a piezoelectric actuator is used to excite the lattice with harmonic loading. Frequency sweeps are performed over varying amplitudes to determine the region and extent of attenuation. Four fiber Bragg grating sensors (FBGs) are used to optically detect strain due to the piezoelectric excitation. Two FBGs are placed along the length of the lattice, and the other two are placed along the diagonal, where the strain response will be considerably less. The region with the high strain can be made thicker than the rest of the lattice. Thus, a structure can be made lightweight by optimizing the materials to manage the propagating stress waves. This research will be applicable to structural protection and health monitoring.

I wish to acknowledge the mentorship of James Ayers.

Enhanced Lifetime Polymers for Nonlinear Optical Materials

Kleine, Tristan

The goal of this project was to develop a polymeric system capable of exhibiting good processability with high Tg characteristics. These characteristics would allow for extending the service lifetimes of polymeric nonlinear optical (NLO) materials. Polymer-based NLOs offer the potential for highly sensitive substrates to detect a variety of wavelengths, including THz radiation. Two approaches are currently under examination. The first approach entails a guest-host system, where the host polymer is a thermally reversible cross-linked matrix and allows for chromophores to be embedded during processing. Two different synthetic routes are evaluated, followed by thermal characterization of the reversible cross-link bond formation. The second approach towards NLO polymers is to create a hyper-branched co-polymer that could be functionalized after the polymerization to covalently bind the chromophores to the side chains. Both approaches should yield a high Tg polymer that could be easily processed into films that may eventually be poled to align the chromophores anisotropically.

I wish to acknowledge the mentorship of Joshua Orlicki and Robert Lambeth.

Hardware Acceleration of the Lucky Region Fusion Algorithm

Koeplinger, David

The imaging of targets through atmospheric turbulence has been the subject of a great deal of optics research and experimentation. Many image processing and video enhancement techniques have been developed to this end, including methods based on “lucky-frame” selection, speckle imaging, blind deconvolution, and local shift removal. Unfortunately, many of these techniques are computationally expensive and, when implemented on conventional computing platforms, are too slow to be used in the field for tasks like live target tracking and identification. However, the U.S. Army Research Laboratory (ARL) Computational and Information Sciences Directorate (CISD) has been developing a relatively computationally inexpensive yet effective video enhancement algorithm based on the “lucky-region” fusion (LRF) approach. Because of this approach’s simplicity, a hardware implementation of this algorithm can potentially increase its processing speed enough to make the algorithm a viable technique for real-time video enhancement. This paper focuses on a hardware implementation of the LRF algorithm on a Xilinx Virtex II field-programmable gate array (FPGA) chip. Several real-time video processing experiments using this FPGA implementation in conjunction with a high frame rate, high resolution image sensor and a deformable pocket mirror are also discussed.

I wish to acknowledge the mentorship of Jory Liu.

An Adaptive Stochastic Differential System for Multi-agent Coordination

Koppel, Alec

Coordination of multi-agent systems in complex environments is a challenging problem and has in recent years motivated approaches from dynamical systems and graph theory. The ability of a multi-agent system to remain coordinated is dependent on communications between the agents, how one defines connectivity, and the environment. A time-dependent sequence of optimization problems was formulated recently using Laplacian eigenvalues of graphs and k-connectivity between relay agents to maintain communications between a leader robot and a base station. This problem was solved numerically using linear programming and gradient ascent to dictate the motion of the relay agents. We generalize this scheme so that the motion of the relay agents follows an adaptive stochastic gradient ascent and interpret their motion as an Itō Process. We then perform probabilistic analysis, discuss algorithmic implementation, and present simulation results for cluttered environments.

I wish to acknowledge the mentorship of Will Nothwang.

Control of an Auxiliary Mini-Robot Supporting an Unmanned Ground Vehicle (UGV): Architecture and Implementation

Kott, Gedalia

Heterogeneous teams of robots and marsupial robots have been used for Urban Search and Rescue (USAR) operations, military missions, and improvised explosive device (IED) detonation, and the need for small, semi-autonomous robots for these purposes is recognized. However, the use of auxiliary mini-robots in support of an unmanned ground vehicle (UGV) is still a challenge due to the limited processing power and costs of developing a mini-robot. Presented in this paper are a concept implementation and an exploratory control architecture comprising a master UGV and a low-cost auxiliary mini-robot (AMR). As a proof of concept and development platform, an iRobot PackBot is used as the UGV and a NXT 2.0 Lego Robot as the AMR with the interface provided by the Robot Operating System (ROS). This example of a control architecture minimizes the cost of an AMR by performing little or no computation onboard the AMR while still providing the UGV with a mobile and data-collection-able auxiliary robot. The AMR can assist in two-dimensional (2-D) cost mapping using a single, low-cost ultrasonic sensor and navigate through areas otherwise inaccessible or too risky for the master UGV. This paper presents the system architecture and the currently implemented cost mapping and navigation capabilities of the NXT robot.

I wish to acknowledge the mentorship of Rick Gregory

Automatic Synthesis of Reverse Event Handlers Through Compiler Analysis

LaPre, Justin M.

During optimistic parallel discrete event simulations, classical state-saving techniques are often used. Interactions with the memory subsystem, however, have become progressively more costly. In light of this, some optimistic simulators choose to largely forgo the state-saving approach in favor of reverse computation. Reverse computation is a method, which, upon detection of an erroneous event or anomaly, runs a user-supplied inverse event handler that returns the simulation to a state prior to the erroneous event. Of course, rollback of a single event may trigger further rollbacks. Reverse computation favors simulations with significantly smaller control-state versus simulation-state. Fortunately, most simulations fall into this category. The purpose of this work is to demonstrate the automatic synthesis of a reverse event handler given its forward event handler counterpart. Using a low level virtual machine (LLVM), we analyze and instrument the control flow graph of the forward event handler, make decisions, invert changes to the global state of the simulation, and return variables to their prior values. Currently, our tool supports full inversion of many arithmetic operations (multiplication and division by zero requires special care), as well as if-else conditional support. Loop support is currently underway and preliminary support is expected by late July/August 2012.

I wish to acknowledge the mentorship of Dale Shires.

Influence of Tile Geometry on the Dynamic Fracture of Silicon Carbide (SiC)

Le, Jacqueline

The Army has spent several years researching and developing ways to improve armor performance while reducing armor weight. One solution is using ceramics to defeat projectiles. The purpose of this study is to see how different sized ceramic tiles react when struck by a projectile. This project examined the response of 19-mm-thick silicon carbide-X1 (SiC-X1) ceramic tiles mounted on 12.7-mm-thick polycarbonate when struck by 12.7-mm-diameter tungsten carbide (WC) spheres. Three different sized SiC-X1 hexagonal tiles were used: 50 mm flat-to-flat, 75 mm flat-to-flat, and 100 mm flat-to-flat. A light gas gun shot the spheres at a nominal velocity of 500 m/s. A high-speed camera was set up to record the back surface of the ceramic and Image-Pro Plus 6.3 was used to analyze the footage from the high-speed camera and quantify failure and fracture of the ceramic as a function of tile geometry.

I wish to acknowledge the mentorship of Shane Bartus.

Implementation of an Inexpensive Decommutation (DECOM) System for Guided Projectile Diagnostics using Field-programmable Gate Arrays

Lee, Eric

Airborne systems often need to send information back to a ground system for analysis, a process known as telemetry. Telemetry is used in guided projectile applications to obtain positional or debugging data during flight for diagnostic purposes. The system involves modulating and randomizing analog data into a digital signal without long strings of similar bits, which improves transmission. Once the stream is received on the ground, the signal is "de-randomized" for decommutation (DECOM), which extracts the transmitted information from each data frame into the correct format. The telemetry stream uses two synchronization words, each of which signals the beginning of a 48-word frame, transmitted at speeds reaching 4 Mb/s. Commercial DECOM systems are bulky and expensive, and often transmit data in a fixed format, which is not ideal for a lab environment. The compact DLP Design field-programmable gate array (FPGA) used in this project is reprogrammable to support different data formats, has a compact footprint and low cost, and has native universal serial bus (USB) support via Xilinx and FTDI chips for integration with existing devices and test benches. Further functionality, such as data integrity checks, encryption, and simplified graphical user interfaces (GUIs) for projectile testing, will be added as required.

I wish to acknowledge the mentorship of Dr. Gary L Katulka and Dr. Michael Don.

Microcontroller Programming to Interface with Digital Micro-electromechanical Systems (MEMS) Acceleration Switch Array for Traumatic Brain Injury Monitoring

Lee, Timothy

Traumatic brain injuries result from exposure to high accelerations and are a serious threat to Soldiers in close contact with improvised explosive devices, as well as athletes who are frequently involved in collisions. In order to better report when immediate care is necessary, an acceleration sensor small enough to be mounted in the ear has been developed. When an acceleration event occurs, an array of three-axis micro-electromechanical systems (MEMS) acceleration threshold switches with different sensitivities ranging from 50 g–250 g move to contacts and complete a circuit. The outputs of the sensor array are processed by a microcontroller and transmitted via a radio frequency (RF) transmitter. The current design uses analog inputs and an analog to digital converter, which causes a minimum delay of 60 microseconds between samples, and, consequently, data loss. We hope to use digital inputs representing the direction and magnitude of the acceleration, and simulate them with an array of switches. The transition to digital inputs is expected to decrease the sampling delay to the order of a few microseconds.

I wish to acknowledge the mentorship of Luke Currano.

Simulation of Steady Plastic Waves with Anisotropic Material Response

Lloyd, Jeffrey T.

Steady plastic wave formulations have been successfully used to simulate the elastic-plastic response of materials in various loading conditions; however, these formulations all assume an isotropic plastic material response. Because slip system level kinematics govern the viscoplastic shock behavior—but cannot be modeled using an isotropic plastic formulation—an anisotropic plastic formulation is created, which admits the response of individual slip system kinematics, yet retains the computational efficiency inherent in steady plastic wave analyses. A thermodynamically consistent formulation that employs second- and third-order elastic constants is presented, which can be applied to any slip system level constitutive hardening relation. A physically based slip system level constitutive equation is applied to weak shock-loading of single crystal Al, and compared to both experimental and finite element simulations that use the same loading conditions. Individual slip system nucleation, multiplication, trapping, and annihilation rates are extracted, and used to interpret the primary mechanisms that govern the single crystal response at different pressures and orientations. A general formulation for simulation of polycrystals is then presented in the context of single-crystal kinematics, which is to be used in future work to predict the weak shock response of annealed and pre-textured polycrystals.

I wish to acknowledge the mentorship of John Clayton.

Social Networking and Cyber Security Best Practices

Lowry, Selena

As a Department of Defense (DoD) component, the U.S. Army Research Laboratory (ARL) at the Adelphi Laboratory Center (ALC) uses certain social networks such as Facebook to show publically approved achievements, research, and milestones. However, users need to be able to recognize the trends and issues of cyber security, social networking, and security best practices in order to make informed decisions on personal and professional computing use. In order to recognize the trends, I took the following steps: (1) investigated the uses and associated regulations of the social networks such as Facebook within DoD policies; (2) developed a security checklist and reference document for ARL social media users; and (3) analyzed the impact of social computing and cyber security threats on individuals at ARL. Future steps will include (4) developing sample firewall and intrusion protection system (IPS) configurations for mitigating possible threats and (5) evaluating and implementing security measures to protect privacy and minimize the risk of cyber attacks.

I wish to acknowledge the mentorship of Thomas Kile, Colleen Adams, the Performance Modeling Team, and the High Performance Networking Team.

Characterization of Gallium Nitride (GaN) Epitaxial Layers Growth

Lucas, Richard

Beginning with a two-lattice-thick substrate ensemble of gallium (Ga) and nitrogen (N) atoms, gallium nitride (GaN) layers are grown in the (0,0,0,1) direction by self-assembly through single atom deposition. While the temperature of the substrate, boundary effects of the in-plane dimensions of the initial substrate, kinetic energy of the deposited atoms, and the parameters of the Large-Scale Atomic/Molecular Massively Parallel Simulator (LAMMPS)-enabled statistical mechanics such as the potential and thermal equilibrium parameters form an array of variables that affect the quality of the grown layers, the quality is usually characterized in terms of the bond angles (the material's electronic properties) and voids and dislocation energies (the material's structural properties). In this work, voids and bulk crystal quality are investigated for a GaN epitaxial layer focusing on voids. I performed centro-symmetric parameter and common-neighbor analyses to obtain a qualitative snapshot of the grown epitaxial layers. Void volume fraction is quantitatively captured by the three parameters: crystal quality, surface roughness, and the actual voids.

I wish to acknowledge the mentorship of Song Park.

Micro-tensile Characterization of Metals Using Digital Image Correlation

Lucero, Dorian

A micro-tension stage has been set up to test tensile specimens on the millimeter scale. Digital image correlation is used in micro- and nanoscale mechanical testing to measure displacement, and thus strain is calculated. In this particular case, Digital Image Correlation in MATLAB® was used to track points along the gauge length of the material for micro-tension testing of various samples at various thicknesses. Samples tested include stainless steel 316 and cartridge brass, both having thicknesses of 0.01 and 0.02 in. G-code is generated via VCarve software, which is read into a computer numerical control (CNC) micro-mill machine. Systematic evaluation of the yield strength and elastic modulus values for a range of materials are underway.

I wish to acknowledge the mentorship of Brian Schuster.

Integration of Compliant Grip Mechanism onto Hovercraft Platform

Maher, Mike

All vehicles are restricted by their physical limitations. The use of compliant structures or robotic mechanisms on vehicles, however, can extensively boost functionality. This paper delves into devices that could possibly offer distinct benefits to hovercraft, mainly focusing on an arm equipped with a compliant gripper. Through the addition of this "tool," a hovercraft would gain the abilities to clear a path for itself, search through debris, and carry, acquire, and deliver a payload. The current focus is to design and fabricate a fully compliant gripper. By concentrating on making the mechanism compliant, weight and power consumption will be drastically reduced, while amplifying input forces and precision. Since there is not yet a true topological method for creating compliant mechanisms, designs will be loosely based off functioning compliant grippers, making adjustments as necessary. Preliminary testing and simulations for stress and displacement are currently being performed in *Solid Works*®, allowing for modifications to be made before fabrication is completed using an Eden 260V®-Objet rapid-prototyping machine. Through various simulation analysis, an optimal compliant gripper can be constructed that will offer various benefits to the hovercraft platform.

I wish to acknowledge the mentorship of Asha Hall.

Hardware Acceleration of Lucky-region Fusion (LRF) Algorithm for Imaging Abstract

Maignan, William

Surveying a target over a long distance is frequently done by government agencies for different purposes. Natural atmospheric turbulence can cause distortions in the received images, however, and the process of improving imaging through turbulence has been studied over a long period of time. Corrective imaging through turbulence normally can be reduced down to two categories, pre-image processing and post-image processing. The Intelligent Optics Lab at the U.S. Army Research Lab (ARL) used the "lucky-region" approach to develop a post image-processing algorithm, Lucky-region Fusion (LRF). The LRF algorithm is able to extract sharp regions of an image obtained form a series of short exposure frames, and "fuses" the sharp regions into a final, improved image. The LRF algorithm previously has been implemented on a PC using a complied programming language. However, the PC does not have sufficient processing power to handle real time extraction and processing. The goal of this project is to implement the LRF algorithm in a hardware description language on a high-speed smart camera that is capable of real time image processing. Successful completion could result in a product that internally corrects an image that is distorted by atmospheric turbulence.

I wish to acknowledge the mentorship of Jony Liu.

Micromechanical Modeling and Characterization of Continuous Ceramic Fiber Reinforced Aluminum Matrix Composites

Mansfield, Charles

Aluminum metal matrix composites (MMC) have become an important area of research as potential lightweight structural materials. Achieving maximum specific properties of these materials requires development of experimentally validated numerical modeling tools to understand the effects of microstructure and processing on the continuum scale mechanical response of MMC, particularly under extreme and dynamic loading conditions. This work presents the development of an experimentally validated micromechanics based finite element model (FEM) for Al-2%wtCu alloy reinforced with continuous alumina fiber. A fiber-scale periodic cell model was used to predict the yarn-scale orthotropic mechanical response of the unidirectional MMC assuming a hexagonal packing array. The model was used to study the effect of fiber morphology on response with fibers having circular and oblong cross-sections. The effect of prior processing history on strain hardening of the Al matrix was accounted for using in-situ nano-hardness measurements. The hardness values were compared to that of the unreinforced matrix and used to scale the response for the input of the model accordingly. Additionally, the model was refined to include delamination at the fiber-matrix interface through the use of cohesive zones. A set of progressive failure/damage parameters for interface failure was determined for the unidirectionally reinforced MMC.

I wish to acknowledge the mentorship of Chian-Fong Yen.

Calculated Localization by use of Targeting Initially Positioned Markers on Remote Manipulators via Visual Sensors

Mark, Mansfield

The purpose of this research was to use teleoperated remote manipulators (RMs) to supplement the capabilities of preexisting iRobot PackBots. The prototype framework for these RMs was framed using the Lego NXT robots. The focus with the RMs was to provide an inexpensive, low-risk solution to examining potentially dangerous or otherwise inaccessible points of interest detected by the larger, more valuable PackBot. One aspect was limiting the necessity of sensors onboard the RMs in an effort to make the RMs more disposable. There is a need to provide accurate relative localization onboard the PackBot as a means of remote navigation. Accurate localization will enable the PackBot to map a precise location of each RM, allowing the PackBot to send commands to navigate the RM without the necessity of each RM running onboard localization hardware. This particular research focuses on the use of passive markers placed upon the RMs that can be detected via a camera on a PackBot. The perceived details of these markers combined with preexisting knowledge of the PackBot's own orientation allows the PackBot to calculate the position of each RM allowing for accurate remote navigation.

I wish to acknowledge the mentorship of Nicholas Fung.

Analysis of Void Defects in NiAl3 Using a Complex Non-local Quasicontinuum Method

Marshall, Jason

The non-local quasicontinuum method finds equilibrium solutions to large atomistic systems that are not computationally feasible with traditional atomisitic methods like molecular dynamics. The current implementation, however, is limited to simple lattices. In this work, I extend the original formulation to complex lattices with potentially different species of atoms. A scalability study was conducted with up to 1024 processors on a shared memory system to determine the computational limits of the formulated implementation. The new complex non-local quasicontinuum method is used to model dislocation nucleation in a large NiAl3 atomistic system with a void defect. NiAl3 is an interesting and potentially highly useful material because of its high thermal conductivity and strength in high-temperature environments. The physics of dislocation nucleation around voids is an important, but poorly understood process. The results of this work provide insight into the underlying physics of the problem. Overall, the newly formulated complex non-local quasicontinuum method provides a way to explore the physics of a large variety of atomistic systems with complex lattices.

I wish to acknowledge the mentorship of Jaroslaw Knap.

Tracking Acoustic Signatures of Moving Military Vehicles for Perception Studies

Mathew, Justin

Military ground vehicles produce specific sounds and that are identifiable to listeners in an environment due to their unique components (e.g., engine type, exhaust system, shape, and wheels). These signatures change as the vehicles move by a listener due to the Doppler Effect. This paper will discuss how much the acoustic signatures analyzed from a stationary high mobility multipurpose wheeled vehicle (HMMWV) diesel-based vehicle, another diesel-based vehicle, and a gasoline-based vehicle are apparent, and change in recordings of them moving past a receiver. The stationary vehicles will be measured with the engine running while audio recordings are taken in grid-like positions in the front, side, and rear of the vehicle using a microphone array. On one side of the path, a microphone array will be placed on the ground, and another placed vertical and perpendicular to the first array. On the opposite side of the path will be the Knowles Electronic Manikin for Acoustic Research (KEMAR) dummy-head. The acoustic signatures of the front, side, and rear of the vehicle will be classified from each other and tracked throughout the moving recordings of the KEMAR dummy-head to investigate the change of these signatures in time. With this acoustic signature analysis, studies can be conducted on subjects to test whether a vehicle's signatures provide clues to where a moving vehicle is in relation to the listener. The recordings from the stationary arrays will be used in future studies on the perception simulations of moving vehicles through loudspeakers.

I wish to acknowledge the mentorship of Mark Anders Ericson.

Prediction of Shear Band Formation and Failure in Aluminum Friction-stir-weld-affected Zones

McAuliffe, Colin

Unibody construction and elimination of fastened joints for Army land vehicles achieves chassis rigidity and structural robustness. A lightweight chassis is desirable for maneuverability and deployability. High strength aluminum alloys are strong and lightweight but difficult to weld. Friction stir welding is a solid-state process capable of joining lightweight, high strength metals. Current capability gaps must be addressed in order to develop understanding and modeling capabilities relating weld process parameters to the weld response for vehicle blast protection. Numerical modeling presents a number of challenges. Material gradients and property differences in various weld zones must be accounted for, including dynamic recrystalization and thermo-mechanical effects. The governing equations and material constitution entail highly nonlinear coupled system, and ductile material failures such as shear bands involve significant strain softening. Finally, finite element modeling results exhibit a spurious dependence on mesh size. A mixed finite element framework permits use of an implicit nonlinearly consistent solution strategy, which solves all fields in a simultaneous fashion without operator splitting. This has produced higher accuracy and mesh insensitivity compared to explicit methods. These computational methods have quantified the strength of friction-stir-welded aluminum joints under blast loading, thus enabling optimization of future vehicle designs.

I wish to acknowledge the mentorship of Ryan Karkkainen.

Efficient Graphical Processing Unit (GPU) Spatial Data Structure Search for Line-of-Sight

McCartney, Joshua

The Ballistic Trajectory Field Calculator (BTFC) is a system designed to find the optimal placement for Soldiers to observe a point of interest while simultaneously minimizing the risk (red-force Soldiers) they are exposed to. This is done by calculating the line of sight for both the points of interest and red-force Soldiers using ray tracing, then determining where to place the blue-force Soldier using a metropolis optimization method. While determining the optimal placement of blue Soldiers is not trivial, especially as the number of blue Soldiers increases, the most time-consuming part of this process is the line-of-sight calculation of red-force Soldiers and points of interest. This work will look at possible ways to improve the performance of the line-of-sight portion of the BTFC by evaluating three different traversal methods—brute force, stack-based, and a stackless approach. Each of these traversal methods will then be evaluated on three different types of spatial data structures—a quad-tree, kd-tree, and a modified kd-tree.

I wish to acknowledge the mentorship of Song Park.

Hovering Flying Wing Hybrid Aircraft

McKinzie, Keith

Current small unmanned aerial vehicles (UAVs) have limitations associated with flight mode. Rotorcraft, such as the quadrotor, can enter and maneuver within buildings, but have a limited range. Fixed wing aircraft travel far, but cannot navigate buildings or execute perch and stare maneuvers necessary for surveillance. A flying wing aircraft with thrust vectoring alternative is capable of perching and staring maneuvers, but with extended range over pure rotorcraft. System identification techniques will be used to identify the vehicle's complex dynamics in order to implement an autopilot. A rigid, static test stand was designed and built to support vehicle system identification in the hover condition using load cells and yaw/pitch location tracking with shaft encoders. A new swash plate was constructed using four servos with optimized slots and servo horn lengths based on the plate geometry. Analysis of the swash plate kinematics revealed that a constraint on the sum of the total servo horn rotation would linearize blade pitch control, and that maximum control authority lies along two perpendicular axes, oriented at 45° to the swash plate axes. These indentified control maxima provide additional control authority for transitioning between forward flight and hover.

I wish to acknowledge the mentorship of Christopher Kroninger.

Design of Flexible Wings for Flapping Wing Micro Air Vehicles (MAVs)

Mishra, Pranay

Bio-inspired flapping wing micro-air vehicles (MAVs) are generally used for reconnaissance and surveillance missions for military applications. For flapping wing flight, insect wings experience inertial and aerodynamic loads in order to deform. The bending and torsional stiffness distribution along the spanwise and chordwise direction of the wing influences the structural response at a given load. The venation patterns in insects are used to create a variable pressure distribution along the wing for optimal flight. In this study, the synthetic wings were measured for their deformation characteristics, resulting in a deflection profile. Each airfoil's flexibility was compared to its aerodynamic properties, such as lift. The goal of this research is to understand the effects the various venation patterns have on the wings. A particular focus has been how wing thickness and stiffness have played a role in flapping amplitude, along with investigating the wind speed, wing deformation, and thrust/lift forces.

I wish to acknowledge the mentorship of Asha Hall.

Temperature-dependant Study of Isobutanol Decompostion

Mitchell, Jonathan E.

The purpose of this work is to identify surface intermediates during the catalytic oxidation of isobutanol in a Fourier transform infrared spectroscopy (FTIR) reaction chamber at various temperatures and equivalence ratios (φ). This was achieved by collecting infrared spectra of surface species and locating peaks that would characterize the presence of these intermediates, such as carbon dioxide (CO_2), olefins, and aldehydes. The reaction was studied using γ-Al_2O_3, Rh/Al_2O_3, and Pd/Al_2O_3 powders as catalysts at temperatures from 100–500 °C over three equivalence ratios: 0.1718, 1.4248, and 3.501. By comparing the ratio of the intensity of the OH peak representative of isobutanol to the intensity of the C=O peak representative of aldehydes, it is possible to elucidate a trend in the activation of aldehyde formation from isobutanol. The results show that increasing temperature promotes aldehyde formation on the surface of the catalyst.

I wish to acknowledge the mentorship of Asha Hall.

Fabrication and Characterization of Superhydrophobic Surfaces to Control Metabolic Heat and Moisture

Mitchell, Joshua

In order to develop lightweight, energy-efficient cooling systems for the Soldier, the U.S. Army Research Laboratory is investigating the possibility of using superhydrophobic surfaces within clothing/gear to rapidly wick away moisture from the body, allowing natural metabolic cooling (via sweating) to continue unhindered. Various methods have been examined for producing copper substrates for subsequent silver depositions. Silver is deposited using aqueous silver nitrate ($AgNO_3$), resulting in a nano- and micro-scale, fractal-like rough surface. A self-assembled monolayer (SAM) is chemically attached to the silver surface from a dilute solution of 1H,1H,2H,2H – perfluorodecanethiol $CF_3(CF_2)_7(CH_2)_2SH$ in dichloromethane (CH_2Cl_2). Surface morphology and properties were characterized at different points in the deposition process using contact angle measurements, atomic force microscopy (AFM), x-ray photoelectron spectroscopy (XPS), and scanning electron microscopy (SEM). Though superhydrophobic surfaces were achieved (contact angles greater than 150°), work continues on producing a surface that exhibits contact angles near 180°. Investigation is continuing on methods of preparing copper substrates as well as devising other methods for quantifying the degree of hydrophobicity.

I wish to acknowledge the mentorship of John Derek Demaree.

Crack Tip Dislocation Nucleation in Cyclotrimethylenetrinitramine (RDX) Molecular Crystals

Mitchell, Robert

This research seeks to verify the anisotropic version of Rice's dislocation nucleation criterion for complex elastic molecular crystal structures. To accomplish this, a cyclotrimethylenetrinitramine (RDX) lattice with a crack tip will be displaced proportional to an increasing mode II load, and evaluated with the Sandia National Laboratories molecular dynamic (MD) code LAMMPS. The objective is to determine the critical mode II loading (K factor) required for dislocation nucleation from the crack tip with MD, and compare this result with the theoretical solution from Rice's model. We anticipate strong agreement between the MD and analytical K factors. If successful, to our knowledge, this will be the first time Rice's model has been used to determine dislocation nucleation in an anisotropic molecular crystal; similar research has been conducted with simple crystalline systems, such as face-centered cubic (FCC) copper, which is well documented in the literature. This research may increase Soldier safety due to better understanding of RDX munition sensitivity related to dynamic inputs; in addition, accurate MD simulations would provide an alternative to potentially hazardous experimental techniques.

I wish to acknowledge the mentorship of Lynn Munday.

Centrality Measures of Dynamic Social Networks

Moore, Allison

Modern criminal networks are constantly changing to maintain secrecy, recruit members, and coordinate activities. Attempts to uncover important elements of these networks need to incorporate dynamic trends to provide useful findings and disrupt harmful plans. Our research provides a promising approach whereby analysts can forecast network behavior and stay a step ahead of their adversaries. This paper explores the theoretical background of dynamic networks, and uses the network measures of degree, closeness, betweenness, and eigenvector centrality over time to conduct network trend analysis. As a case study, we examined the Ali Baba data set that provides messages from a fictitious terrorist cell over a seven-month period. The force-directed Fruchterman-Reingold algorithm was used to visualize the Ali Baba network each month to identify structure, distinguish key players, and understand behavioral roles. Despite the low density of interactions, results revealed the ranking of eigenvector centrality to match the terrorist attack cycle. Several methods for centrality measure prediction are also evaluated, including regression and moving average. Lastly, the results of the removal of a key node from a scale-free criminal network are examined. These examples are an important step in the continuing effort to predict terrorist network behavior.

I wish to acknowledge the mentorship of Elizabeth Bowman.

Response of Friction-stir Welded Aluminum as a Function of Loading Rate

Morgan, Alex

Conventional methods for welding aluminum (Al) are more technically challenging than for steel—they are time consuming, difficult, and less effective for joining different Al alloys. A new and effective method to join Al plates is friction-stir welding (FSW). The FSW process does not melt the base metal, leaving the mechanical properties less altered. The FSW process creates three zones: base metal (BM), weld zone (WZ), and heat-affected zone (HAZ). In this study, two Al plates were joined using FSW, and specimens were taken from the base Al material (2139-T8) and the WZ. Specimens were extracted that spanned across the plate, which allowed the completed plate structure to be characterized in tension. Experiments were conducted to measure how tensile strength varies as a function of position relative to the WZ. In addition, experiments were conducted at several loading/strain rates to investigate rate dependency of the material from the different zones, although, generally, the response of Al is relatively rate insensitive. The results show that the FSW significantly creates a zone of reduced tensile strength, where tensile strain concentrates.

I wish to acknowledge the mentorship of Allen Gunnarsson.

Carbon Dioxide (CO_2) Transport in Nafion and Anion Exchange Membranes

Myles, Timothy

In this study, experiments of cabon dioxide (CO_2) permeation through polymer electrolyte membranes for fuel cell applications were conducted. Combined with modeling efforts, a better understanding and quantitative prediction on processes related to CO_2 and bicarbonate sorption, transport, and exchange processes in an anion exchange membrane (AEM) can be achieved. In the experiment, a CO_2 step pulse was introduced at one side of the membrane and the CO_2 flux permeating through the membrane was detected with an infrared (IR) based CO_2 detector for both transient and steady states. Simultaneous membrane conductivity measurements were performed to observe the progressive conversion of the AEM membrane from the hydroxide state to a carbonate/bicarbonate state. To validate the experimental procedure, Nafion and Teflon membranes were studied and compared with the extensive literature data available. Significant changes in CO_2 transport through the Nafion membrane as a function of membrane treatment history, temperature and humidity were observed, which reflects the corresponding changes in Nafion membrane structure, especially the channel structures important for transport properties. Similar studies were applied to the AEM membranes and the results were compared to those of the Nafion membranes. Other aspects affecting CO_2 transport in an operating fuel cell, effects of gas diffusion layer (GDL) and catalyst layer (CL) on transport were also studied.

I wish to acknowledge the mentorship of Xiaoming Ren.

Modeling Negative Index-of-Refraction Metamaterials using POV-Ray

Nataraj, Chiraag

The motive of my research is to investigate the possibility of creating “hide-in-plain-sight” effects using negative index metamaterials (NIMs). The objective is to determine if and how it is possible to use NIMs in order to conceal or disguise an object. In order to investigate these questions, POV-Ray, a ray tracing software, is used to model negative index-of-refraction metamaterials in various configurations. Investigations are conducted based upon varying geometry and gradients of index of refraction to study the effect on an observer’s perception of an object enclosed in metamaterial. Results indicate that reflectance and transmittance of a given object are the same whether the index of refraction is positive or negative. Furthermore, using certain combinations of metamaterials and ordinary materials, a variety of optical effects can be achieved. Finally, at certain viewing angles, NIMs are not necessary in order to produce “hide-in-plain-sight” effects; positive index of refraction metamaterials would also work. The present results portend that “hide-in-plain-sight” may not be far off in the future.

I wish to acknowledge the mentorship of Jaret Riddick.

Digital Data Acquisition & Analysis System for Isomer Experiments

Netherton, Kaatrin A

Nuclear isomers are excited bound states of atomic nuclei that have measurable lifetimes, with "storage isomers" having lifetimes of years or longer. Given the correct stimulus, these isomers may be "switched" to release energy, similar to a battery or a capacitor. Measurement of switching efficiency is one of the U.S. Army Research Laboratory's (ARL) research interests. Experiments require radiation detectors and associated instrumentation to collect and store the raw data, while sorting programs are necessary to translate that data into a meaningful form. Digital Data Acquisition and Analysis System for Isomer Experiments (*D^2A^2SIE)* functions as a matched hardware-software system to collect data from multiple detectors, store them, and then provide subsets of the data in a form that can be analyzed. The Java program *PixieTools* functions as a bridge between the raw data acquisition system and the user, allowing for easy manipulation of the data to the users' needs. In addition, the flexibility of the system allows it to be employed for different types of isomer experiments ongoing and planned at ARL, for which multiple signals must be recorded. Examples of these experiments using *D^2A^2SIE* will be discussed.

I wish to acknowledge the mentorship of James Carroll.

Flight Control Performance of Affordable Precision Munitions

Ostendorf, Nicolaas

This paper investigates the application of flight control to a fin-stabilized projectile with canards. The derivation of this autopilot is based on linearized flight dynamics. The cost-performance characteristics of this flight-control approach were examined for the gun-launched environment. System stability was investigated through pole mapping as well as gain and phase margins. An analysis was conducted on the simulated response to guidance commands. A trade study was conducted to examine the effects on the system stability and acceleration response through alterations of the actuator frequency, the flight control system's time constant, and the normal force experienced by the canards (physically accomplished through alterations of the canard dimensions). High actuation speeds produced a quick response with short convergence time, while slow actuation speeds showed an overshoot past the commanded acceleration. Increasing the canard normal force reduced the overshoot when using slow actuation speeds.

I wish to acknowledge the mentorship of Frank Fresconi.

Pragmatic Performance Analysis of a High Performance Computing Resource

Padron, Omar

A case study in performance benchmarking of a distributed-memory computer cluster is presented. The benchmark test suite is constructed from a number of sample applications that resemble those used to solve real-world science and engineering problems (in particular, with respect to their patterns of computation and input/output [I/O]). A pragmatic approach is outlined, which was used to prepare, execute, and evaluate the suite. Process scripting is used to coordinate the execution of the suite, database management provides adaptable storage of various metrics, and textual data processing facilitates the collection and post- processing of performance results. The method outlined is intended to be both practical and general, and immediately applicable in a variety of other parallel production computing scenarios.

I wish to acknowledge the mentorship of Dale Shires.

Investigating Lateral Boundary Forcing of Weather Research and Forecasting (WRF) Model Forecasts for Artillery Mission Support

Pattantyus, Andre

Accuracy of global numerical weather prediction (NWP) models is highly dependent on initial atmospheric conditions. Model error grows primarily from poor initial conditions. Dozens of physical parameterizations also have secondary influences on model accuracy or error/variability. Limited area models (LAMs) have an additional source of error/variability from their lateral boundaries, which are forced from global models or other LAMs. Lateral boundary forcing can be a substantial source of error/variability for LAMs due to interpolation of course atmospheric data down to finer grids and higher resolution topography. Domain size has been identified as a way to control the spatial spin-up and internal variability of LAMs caused by lateral boundary conditions (LBCs). Past research has found that larger LAM domains provide more freedom for the model to create its own solution, while smaller domains are dominated by the forcing from the lateral boundaries. U. S. Army artillery relies on LAM output from weather research and forecasting (WRF) to correct long-range trajectories for atmospheric conditions. Sensitivity testing of the WRF to LBCs over Central Europe is performed in this study. Initial results suggest no substantial difference between large and small domain experiments, except that the magnitude of error is greater for larger domains.

I wish to acknowledge the mentorship of Robert Dumais.

Stimuli-responsive Materials Toward Enhanced Performance Lifetimes

Pattillo, Chris

Developing materials that respond to desired stimuli has become a major field of research in recent years. Recently, two major avenues of research in this field have been in the areas of thermally reversible cross-linked materials and detection of corrosion. This work focuses on the development of responsive and efficient materials for these applications. A reversibly cross-linked polymer matrix can exhibit good processing characteristics and long-term stability, and a polymer matrix displaying these properties through the use of Diels-Alder (DA) chemistry was investigated. Diene/dienophile moieties were installed via co-polymerization of specialized monomers with styrene and methyl methacrylate. An alternative method centered on the preparation of a styrene (or MMA)/maleic anhydride copolymer, allowing for the installation of DA moieties as pendant groups to the polymer chain. Stimuli-responsive dyes for applications in corrosion detection were also investigated. Upon corrosion, metal ions are released, and a properly functionalized dye can be made to fluoresce in the presence of these ions. A series of rhodamine B and fluorescein dyes were prepared to test the steric and electronic effects of substituents on both metal binding and the degree of fluorescence. Various concentrations of dye were tested in coatings to determine the ideal concentration for fluorescence detection.

I wish to acknowledge the mentorship of Joshua Orlicki and Andre Williams.

Surface Recombination Velocity of Atomic Layer Deposition Passivated Mercury Cadmium Telluride

Pattison, James

Charge carriers in mercury cadmium telluride (MCT) have high surface recombination velocities, which require passivation for optimal device operation. The high aspect ratio features in state-of-the-art MCT devices for advanced infrared (IR) sensor technologies present a challenge to deposition of electrical passivation materials. Deposition of aluminum oxide (Al_2O_3) onto MCT near room temperature by plasma-assisted atomic layer deposition (ALD) was studied. Conformal deposition was demonstrated through scanning electron microscope (SEM) images of thick (ca. 150 nm) deposition onto high aspect ratio features dry-etched into MCT. Temperature-dependent lifetime spectra (TDLS) were obtained by minority carrier photoconductive decay transients in MCT before and after ALD deposition. In addition to TDLS, single temperature decay transients were excited by two different wavelengths (635 nm and 1550 nm) and compared in order to extract surface recombination velocity (SRV). Complementary to empirical SRV determinations, a diffusion-based theoretical model was invoked to fit the transient decay data.

I wish to acknowledge the mentorship of Priyalal Wijewarnasuriya.

Comparison of Purification Methods in the Production of Photoactive Yellow Protein (PYP)

Pennington, Joseph M.

Producing recombinant proteins in *E. coli* requires the initial purification of large yields of very pure protein. Due to the complexity of proteins, affinity purification methods have been developed to simplify these processes, often through the addition of a labile tag. Three common purification methods were attempted, His-tagging, fusion with a chitin binding protein, and production of the native photoactive yellow protein (PYP). Difficulty in removing the labile tags was hypothesized to be caused by the acidic properties of PYP, leading to unsuccessful cleavage of the His-tag as well as the fused chitin binding protein. Therefore, purification of native PYP was completed using a three-step process involving separation by anion exchange, size exclusion, and hydrophobic interaction chromatography. This resulted in the in-house production of high yields of PYP with a purity >98% as determined by highly sensitive silver stains.

I wish to acknowledge the mentorship of Joshua Kogot.

Strength Testing of Binders on Low Observable Tracer Rounds

Perez, Daniel

Low Observable Tracer (LOT) rounds are set to replace the current pyrotechnic tracers with the intention of reduced visibility from the enemy. A non-combustible phosphor material will provide a traceable trail for the shooter while still maintaining the trajectory of a non-tracer round. A binder is necessary to hold the phosphor material to the back of the round, and the adhesive chosen must survive stresses exhibited onto it from flight and firing. Twelve adhesives ranging from epoxies to resins to polyurethanes had their bond strength between the specimens measured and were used to determine which adhesive is best suited as a binder. Tensile testing and lap shear testing was performed at room temperature to acquire shear and tensile strength results used to compare the different adhesives. Of the 12 binders studied, six satisfied several criteria, including shear strength, tensile strength, and cost to produce to the next phase of study.

I wish to acknowledge the mentorship of Andres Bujanda.

Design of Spectrally Versatile Forward-looking Ground Penetrating Radar for Detection of Concealed Targets

Phelan, Brian

The design of high-resolution radars that can operate in theater involves a careful consideration of the radar's radiated spectrum. A wide bandwidth yields better target detectability and classification but can interfere with other devices and/or violate federal and international communication laws. The U.S. Army Research Laboratory (ARL) Partnerships in Research Transition (PIRT) program is investigating the design and development of a stepped-frequency radar (SFR), which allows for manipulation of the radiated spectrum, while still maintaining an effective ultra-wide bandwidth. The SFR is a forward-looking, ultra-wideband (UWB) imaging radar capable of detecting concealed targets. This paper presents the research and analysis undertaken during the design of the SFR, which will eventually be implemented in an existing ARL system, the Synchronous Impulse Reconstruction (SIRE) radar. The SFR is capable of excising prohibited frequency bands, while maintaining the down-range resolution capability of the original SIRE radar. The SFR, like the SIRE radar, is a vehicle-mounted, forward-looking, ground penetrating radar (GPR) capable of using synthetic aperture radar (SAR) technology to produce suitable cross-range resolution for detection of sub-surface targets. The selection of system bandwidth, antenna types, number of antennas, frequency synthesizers, digitizers, receive amplifiers, wideband splitters, and many other components are critical to the design of the SFR. This SFR design will result in an ARL asset to support obscured target detection, such as improvised explosive devices (IEDs) and landmines.

I wish to acknowledge the mentorship of Kelly Sherbondy.

Formation of Aluminum-Based Intermetallic Compounds with Early Transition Metals

Plunkett, Kenneth F.

Equiatomic mixtures of Al and the six early transition metal powders in Groups IV and V (i.e., Ti, Zr, and Hf; and V, Nb, and Ta) were subjected to high energy mechanical alloying. The blends were subjected to microscopic examination and differential thermal analysis to systematically investigate the efficiency of conversion from reactants to products. Specifically, each of the Al-X blends was created by the use of cryomilling the pure elemental powders with 1.5 wt% stearic acid to prevent cold welding to the milling vial's internal walls during the blending process. Powder samples were extracted for analysis at 1, 5, or 20 min to determine the effect of milling time on the total heat released. The as-milled powders were analyzed via scanning electron microscopy (SEM), energy dispersive x-ray analysis (EDS), x-ray diffraction analysis (XRD), and subjected to differential scanning calorimetry (DSC). SEM, EDS, and XRD analyses were performed prior and after DSC to compare the morphologies of the reactants and products, as well as to determine the bulk phases present in the product as they relate to the equilibrium phase diagram for that particular mixture. The DSC analysis was performed to measure and determine the total energy released from the mixtures while being heated to 1000˚C at 10 K/min.

I wish to acknowledge the mentorship of Laszlo Kecskes.

New Methodologies for the Rapid Detection and Identification of Hazardous Compounds

Proctor, Thomas

The U.S. Army Research Laboratory (ARL) is exploring a process allowing Soldiers in the field to rapidly detect and identify the presence of hazardous compounds by combining existing technologies in smart phones and colorimetric explosive detection assays (CEDAs). Exploiting existing smart phone technology in the battlefield can reduce the logics load of the Soldier. This study uses commercially available wipe-based detection kits, where the operator wipes the surface of a suspected area using special detection paper. Next, drops of certain reagents are added to the detection paper in a specific order to elicit a color change if explosive compounds are present. Currently, experiments are being conducted to systematically test these commercial CEDA kits to determine the limit of detection (LOD) and refine the experimental conditions in a controlled laboratory setting. While a solution-based CEDA is more advantageous, a variety of commercially available explosive detection kits are being used to determine if they could be universally incorporated into smart phone cameras. Smart phones are used to detect, quantify, and archive CEDA results with image, global positioning system (GPS) coordinates, time, and date. This technology could allow life-saving, quick, and accurate detection of explosive by any Soldier with a smart phone camera.

I wish to acknowledge the mentorship of Amy Finch.

High Energy Density Supercapacitors

Raju, Vinay

Supercapacitors are electrochemical energy storage devices that are renowned for high energy density compared to other capacitors, and high power density compared to batteries. Graphene, a single atomic layer of the compound graphite, has the potential to store high amounts of energy. This research will deal with maximizing capacitance for graphene-based supercapacitors by adding pseudocapacitive components. One particular additive that will be used in my research is manganese oxide nanoparticles. These nanoparticles are unique because they can produce fairly significant capacitances through reversible redox reactions. Adding manganese oxide nanoparticles to graphene oxide or graphene derivatives should result in higher capacitance in the form of psuedocapacitance. There are several methods that will be investigated for fabrication of graphene/manganese oxide composites and electrodes, including dropcasting or air-brushing. The challenge involved here is to optimize the composition and electrode morphology to achieve the maximum energy density. Overall, supercapacitor research can go a long way in determining how to meet the energy needs of our Soldiers.

I wish to acknowledge the mentorship of Matthew Ervin.

Testing Latency and Security in Integrated Distributed Virtual Research Network (IDVRN) using WireShark

Ramgolam, Asha E.

The High Performance Networking Branch (HPNB) maintains a collection of Virtual Local Area Network (VLAN) enclaves, which allow researchers to conduct their research in a safe and secure environment known as the Integrated Distributed Virtual Research Network (IDVRN). This project is designed to test and analyze latency and security in the IDVRN using a tool named WireShark. WireShark is an open source tool that will interactively capture packets and measure the time it takes a packet to travel from its source to the destination. Along with testing latency, graphs will be created to provide a visual of the delta time values. Security will be analyzed based on identifying traffic, if any, that has bypassed the firewall policies and why. This can be determined by properties such as an IP address and/or protocols. Based on the results from this experiment, possible solutions will be formulated and tested to help improve any latency or vulnerabilities within IDVRN.

I wish to acknowledge the mentorship of Mrs. Colleen Adams, Kim Nguyen, Tom Kile, Jason Wilkins, Selena Lowry, Shelly Davis, and Paul Price.

Titanium Hydride Powders and Controlled Atmosphere Sintering of Hydrides (CASH) Process

Ramos, Katherine

Titanium's high strength-to-weight ratio and exceptional corrosion resistance makes it extremely valuable and useful for various industrial applications. However, the greatest challenges for these industries are the high cost and low yield of traditional wrought processing. The recently developed Controlled Atmosphere Sintering of Hydrides (CASH) process provides a new way to successfully produce fully dense titanium alloys with mechanical properties exceeding that of wrought titanium. CASH consolidates and dehydrogenates titanium hydride powders via simple press and sinter methods. The U.S. Army Research Laboratory is currently investigating CASH as a means to produce near-net-shape titanium components with significantly lower processing costs. This study analyzes two prospective feedstock materials for the CASH process: traditional, high-purity titanium hydride powder produced as an intermediary of the hydride-dehydride refinement process and a low-cost titanium hydride powder formed via hydrogenation of titanium produced by the Armstrong process. The initial analyses involve taking loose, tap, and green densities at various pressures to determine compaction characteristics. These data are compared with the morphology of the powders using optical and scanning electron microscopy (SEM). Both powders are pressed and sintered using CASH to achieve full densification; metallography is performed for microstructural analysis. Lastly, mechanical and chemical testing determines the strength, ductility, and purity of the samples.

I wish to acknowledge the mentorship of Brady Butler and James Paramore.

PackBot Platform Deployment via Android Device Running ROSJava

Rao, Chirag

Currently, the iRobot PackBot® platforms used for autonomous and semi-autonomous robotic systems development are controlled by laptop or desktop computers running the Robot Operating System (ROS). A user can provide the robot with a waypoint goal via the computer, and then the robot can plan its path to the goal. This setup allows for interfacing between user and platform in an enclosed setting with a reliable source of power, such as an office environment. However, such a setup is not ideal for warfighters in combat, who need a portable way of controlling semi-autonomous systems. This is the motivation for developing a ROSJava application that allows users to deploy PackBots using waypoint navigation on portable Android devices. The first step towards developing this application is creating the graphical user interface for the Android, which would include buttons for changing the degree of control users have over the robot (e.g., autonomous mode, manual mode, or waypoint navigation mode), as well as a display panel for the two-dimensional map the robot generates. This is the step that is currently under development. Future tasks would include translating existing software for waypoint navigation functionality from the C++ programming language to Java.

I wish to acknowledge the mentorship of Reginald Hobbs.

Implementing a Global Path Planner with History-dependent Costs Based on Robot Kinematics over Variable Terrain

Rayas, Luis

The majority of common global path planning techniques are abstracted from the low- level motion planning of the robot, which provides modularity between the two. However this comes with the disadvantage that the high-level planner may find a path requiring infeasible or difficult maneuvers for the robot, such as overly tight turns. There exist efficient algorithms that search for a path through the cost-map using only known, feasible maneuvers; however, these solutions only provide yes or no answers to path feasibility. A previous developed solution for this involves creating a graph of history-dependent nodes from a cost-map of the environment, which can then be used with any path finding algorithm such as A* or Dijkstra's. This process allows the robot to assign a large cost to difficult but feasible maneuvers without excluding them outright, which is advantageous if the optimal path requires such maneuvers. We focus on the practical implementation of such an algorithm as a generalized Robot Operating System (ROS) package along with the required interface for using it with an iRobot PackBot.

I wish to acknowledge the mentorship of Brendan Byrne.

Linear Combination of Classifiers by Sparse Reconstruction

Reale, Christopher

A novel method for combining binary classifiers in a linear fashion is presented. The aim is to optimally trade-off between the number of classifiers used and the accuracy of the combined classifier. This problem is solved by reformulating it as the reconstruction of a sparse signal with the true classes of the training data acting as the signal to be reconstructed and the classifiers as the atoms of a dictionary. In this framework, the L^1 norm is minimized subject to an upper bound on the reconstruction error. The algorithm performs on par with Adaboost on synthetic data when the standard Euclidian distance metric is used as the error term in the optimization. Currently, an optimization algorithm is being developed that can use other (potentially non-convex) error terms that better approximate of the misclassification rate of the combined classifier. The method will then be applied to train classifiers for use in a cascade of rejecters framework for human detection. Because of the minimization of the number of classifiers for a given classification error, the cascade will be able to process video at a higher frame rate.

I wish to acknowledge the mentorship of Alex Chan.

High Selectivity Assay For Detection of Hypersporulating *B. Atrophaeus var Globigii* in Environmental Samples

Ren, Suelynn

In this effort, we develop a selective and sensitive assay for detecting the hypersporulating strain Detrick-2 of *B. Atrophaeus* var. *globigii* (BG) in environmental samples. Detrick-2 and its progenitors are the Army simulant for anthrax, and is believed to have been intentionally selected for in the early 1950s. To test this hypothesis, we developed a phenotype-based forensic approach and confirmed that Detrick-2 was selected in manmade conditions. As part of this effort, we developed a single nucleotide polymorphism (SNP)-specific quantitative polymerase chain reaction (qPCR) assay to detect the C:T substitution corresponding to the (H101R) Spo0F mutation, which defines the hypersporulating phenotype. This assay had selectivity 1:1.000, which was not sufficient for use with environmental samples; we aim to extend this selectivity to 1:100,000. This will provide Army researchers a new tool for detecting hyper-sporulating strains in environmental samples and allow experiments not presently possible to be conducted. To achieve this selectivity, we are designing a clamp to target the mutation site and act in the first step of a nested PCR. Thus far, we have successfully designed a clamp that matches Detrick-2 and retards its amplification. Using this clamp, we have achieved detection levels of 1:100,000 of Detrick-1. A similar assay is being developed to detect Detrick-2.

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WAM14- Loss of Oil Component Testing

Riggs, Mark

The focus of this research is to gain a better understanding of helicopter mechanical components under loss-of-oil running conditions. The current method for resolving a loss-of-oil situation is implementing a backup oil supply with a minimum life of 30 min. However, this is often not enough time to return from a mission, and the backup supply's weight is costly to haul. New methods for dealing with a loss of oil will be investigated with the help of the Wedeven Associates Inc. machine, WAM14. The WAM14 is a flexible tribology testing machine that uses a ball-on-disk method for replicating the contact stresses experienced within rolling element bearings and many types of gears. Baseline tests at normal operating conditions and loss-of-oil tests with a limited oil supply will be performed to collect data concerning the interfacial and chemical interactions. Knowing the behavior of mechanical components under extreme conditions is imperative to formulating an intelligent solution. Through an exploratory test matrix, the WAM14 will help take the first step in creating a design that reduces weight and extends the life of helicopter gears and bearings under a loss of oil condition.

I wish to acknowledge the mentorship of Brian Dykas.

Drafting a Manual for Impulse Noise Attenuation Measurements

Roberts, Miller

Hearing is one of the most important ways that a Solder collects information about his or her environment. However, Soldiers often work in hazardous noise environments; thus, their hearing requires protection that allows them to remain sensitive to their surrounding environment. Level-dependent hearing protector devices (HPDs) are triggered by high intensity impulse noise (weapons fire), but provide little attenuation at low intensity levels, allowing the user to hear his environment. One job that is performed in the Environment for Auditory Research is measurement of impulse noise through level-dependent HPDs to determine the degree of protection offered. A system consisting of a "shock" tube, binaural auditory test fixture (with microphones and preamplifiers), reference microphone, analog-digital converter, and laptop was developed to generate and record the attenuation of impulse noise by level-dependent HPDs. The system's use requires an understanding of calibration, signal processing, and audio engineering principles in order to consistently and accurately test attenuation levels. This presentation documents the recording process in preparation for the creation of a reference manual, allowing people with no prior knowledge of the system to use it effectively.

I wish to acknowledge the mentorship of Dr. Angelique Scharine.

Indoor and Outdoor 3-D Mapping with a Ground Robot

Rogers, John G. III

The military relies on unmanned systems for situational awareness, security, and dangerous tasks like disarming improvised explosive devices. Unmanned aerial vehicles (UAVs) are used to provide situational awareness in a large open area, but are unable to see inside buildings. Man-portable unmanned ground vehicles (UGVs) are used to provide situational awareness inside buildings with minimal risk to personnel. By augmenting these UGVs with sensors and computation, more complete and relevant situational awareness can be delivered to the warfighter. We have developed a software suite called *Omni-Mapper*, which can process data from many types of sensors on a mobile robot to build a three-dimensional (3-D) map. The recent developments described in this paper include a new module that can work in both an unstructured outdoor scene as well as indoors. Additionally, global positioning system (GPS) data can be used, when available, to geo-reference map data, so it can be merged with data from other agents such as UAVs. We present results from testing our algorithms on data collected from urban combat training sites at Camp Lejeune, NC, and at Ft. Indiantown Gap, PA, in addition to that collected at our robot test facility.

I wish to acknowledge the mentorship of Ethan Stump.

Advanced Suspension Modeling

Rogers, Mark

Traveling over rough terrain can fatigue the Soldier and impair battlefield mobility. Thus, high-performance adaptive suspension systems are in high demand. Semi-active components are one new innovation of suspension technology. The test rigs required for semi-active suspensions must be characterized and translated into a mathematical model so that simulations can be generated and semi-active control systems can be developed. To that end, a test rig simulating a quarter-car model was created to allow for the tuning of a variety of different suspension parameters, such as applied masses, and both spring and damping coefficients. It was mounted on a load frame, which simulates disturbances to a vehicle generated by uneven terrain. The test rig was integrated with requisite instrumentation to give status information to a data acquisition unit. Then, after being mounted on the load frame, the behavior of the test rig was characterized and an appropriate mathematical model was defined. The model will be programmed into Simulink, which will enable several different closed-loop simulations to be run using a variety of different control algorithms. In the future, the rig will be vital to hardware-in-the-loop testing of new damping mechanisms and control algorithms.

I wish to acknowledge the mentorship of Muthuvel Murugan.

Domain-specific Keyphrase Extraction Application and Evaluation

Rose, Gabriella

The automatic extraction of salient terminology in a technical corpus is a relatively small field, yet crucial to the military's immediate need for effective summarization of documents, domain identification, and ontology learning. The central objective of this study is to evaluate our existing terminology extraction system on a series of tasks that we find valuable in support of our current mission: dictionary and glossary formation. For the purposes of this investigation, we define a single domain by using the recently validated Machine Foreign Language Translation System's (MFLTS) priority domain inventory in conjunction with the Jensen-Shannon (J-S) equation to measure document distance and divergence. We then train and tune our existing system to the established domain, and extract new pertinent keyphrases from a document of similar content. A thorough assessment of our in-house tool will allow us to identify problematic areas to correct. This will allow us to strengthen the quality of our term extraction process and build databases of technical terms for topic areas such as those represented by the MFLTS domains.

I wish to acknowledge the mentorship of Stephen LaRocca.

Modeling an Ultrasonic Motor: From Fundamentals to Performance Metrics

Rudy, Ryan

Since the traveling wave ultrasonic motor (TWUM) was introduced in 1983 by Toshiiku Sashida, many researchers have developed models to estimate performance characteristics like speed and torque. Many of these models are an excellent fit to experimental torque-speed curves by leaving many parameters open. This leads to an accurate mathematical model for an experimental curve, but is not useful in design optimizations, where no such experimental curves exist. Some researchers have attempted to model a TWUM without leaving numerous parameters open; however, these models depend on already-identified vibration mode shapes. This work extends the previous modeling efforts to arbitrary vibration mode shapes using basic geometric and material properties to identify arbitrary vibration mode shapes and corresponding natural frequencies. With these mode shapes, actuation is simulated using an effective electromechanical coupling factor at or near the resonance frequency. The vibration mode shape is then used to determine the torque and speed characteristics of the rotor. Optimization of a TWUM using this model is also discussed, taking into account performance characteristics such as torque, speed, and efficiency.

I wish to acknowledge the mentorship of Ron Polcawich.

Measurement of the Wavelength-dependent Group Delay Using White Light Interferometry

Rugel, Kelly

The duration of ultrashort laser pulses can be altered by dispersion added after interaction with dielectric mirrors, lenses, and polarizers. The use of white light interferometry in a controlled laboratory environment can be used to determine whether the optical components *(e.g.*, broadband dielectric mirrors) used for ultrashort laser pulses have been properly produced by measuring wavelength-dependant group delay and chromatic dispersion. The group delay imparted to the pulse in this experiment will be determined by using a Michelson interferometer. Upon temporal overlap of the two white light "pulses" from the different arms of the interferometer, spectral and spatial interference fringes will be observed. By applying an algorithm to the collected data, the group delay and chromatic dispersion resulting from a broadband dielectric optical element can be determined. The collected data can be compared against a manufacturer's theoretical and/or experimentally measured data to determine the best optics necessary to maintain the ultrashort laser pulse duration. If the group delay curves are inconsistent, then that broadband dielectric mirror must be replaced to properly maintain the femtosecond laser pulse duration. Such considerations must be made when using custom optics manufactured for single beam coherent anti-stokes Raman applications.

I wish to acknowledge the mentorship of Ellen Holthoff and John Brady.

Photovoltaic Tritium Battery

Russo, Johnny

The need for longer lasting batteries is of great interest to the Army, especially in operations taking place in remote locations. Unattended sensors can operate in remote locations, providing information to leaders through the use of extended lifetime power sources and low-power sensors. The current chemical battery technology has lifetimes limited to five years, even if no power is consumed. To increase this time period to decades, researchers have been conducting experiments with isotope power sources. A tritium-based source has been designed to achieve indirect power conversion (tritium exciting a phosphor as light source). The electrical power generated from indirect conversion is calculated to be 100 µW, which will allow for remote communication of sensors. The gaseous tritium is encased in a phosphor layer inside glass undergoing beta decay, releasing electrons. This causes the phosphor layer to fluoresce and radiate green light. The green light (optical energy) is then captured by photovoltaic cells placed on each side of the light source. The photovoltaics convert the low light radiation into DC electricity. The power sources are constructed into packets, connected in parallel, and attached to circuit boards. The circuit boards are placed in enclosures, where they will be connected to produce a constant 100 µW for years in duration.

I wish to acknowledge the mentorship of Marc Litz.

Estimating Environmental Parameters with 3-Dimensional Acoustic Arrays

Sanchez, Kevin

The U.S. Army has used several acoustic systems designed for detecting, locating, and classifying battlefield sounds. Many environmental parameters such as ground impedance, temperature gradients, terrain, and wind speed and direction can modify signals. If possible, it would be useful to calculate these parameters and incorporate them into models to improve the accuracy of locating and classifying sounds. Previous studies have shown that wind speed and direction can be calculated from microphone recordings of wind noise. However, these studies did not include windscreens, which are designed to mitigate wind noise. To determine if windscreens make it impossible to calculate the wind speed and direction, sonic anemometer measurements were compared to estimated wind speeds and directions from a three-dimensional array of microphones with and without windscreens. Another parameter, derived using acoustic arrays, is the acoustic ground impedance. Current standards in ground impedance measurement methods require two microphones to be placed vertically over one another, contrary to how typical three-dimensional acoustic arrays are configured. By re-deriving and adjusting equations currently used for impedance measurements, the ground impedance can be estimated with microphones that are not vertically aligned. Experimental results of wind speed and direction and ground impedance estimates will be discussed.

I wish to acknowledge the mentorship of William Alberts.

Texture Optimization of $Pb(Zr_{0.52}, Ti_{0.48})O_3$, Lead Zirconate Titanate (PZT) (52/48), Single- and Multi-layer Thin Films

Sanchez, Luz

Lead zirconate titanate (PZT) thin films are used in MEMS devices due to their excellent electrical and piezoelectric properties. (001)-oriented PZT films at the morphotropic phase boundary (MPB), located around the (52/48) Zr/Ti ratio, have shown a substantial improvement in properties, leading to further research in the area. During the thermal treatment of PZT (52/48) during the crystallization step, lead (Pb) is volatilized from the films, leading to a non-stoichiometric state and a deformation in the PZT unit cell that ultimately reduces the electrical properties. To remedy this issue, a percentage of Pb-excess is added to the PZT solution prior to deposition to compensate for the Pb that is lost during the thermal treatment. In the opposite case where there is an excess of Pb in the final film, the Pb atoms create conduction pathways, leading to shorting and breakdown of devices. This study thoroughly evaluates the effects of the Pb-excess in the $PbTiO_3$ seed layer with percentages of 0%, 10%, 15%, 20%, and 30%, and PZT (52/48) with Pb-excesses of 0%, 3%, 5%, 8%, and 10% combined in varying ratios. The x-ray diffraction (XRD), electrical properties, and displacement of cantilevers will be analyzed to determine effects of Pb-excess on orientation and film properties. Additionally, thin film capacitors and cantilevers will be fabricated and characterized electrically and mechanically.

I wish to acknowledge the mentorship of Ron Polcawich.

B-H Evaluation Control System

Santangelo, Elizabeth

Several fundamental characteristics of magnetic materials may be obtained from the measurement of the magnetic flux density (*B*) as a function of magnetic field (*H*). Most conventional measurement systems use low-power, sinusoidal stimuli to obtain the *B*-*H* characteristic from which core loss is extracted. However, the sinusoidal-based data do not give the same core loss estimate for switched-mode power supply (SMPS) applications as the magnetic components are subjected to *square*, pulse width modulation (PWM) excitations. In this project, I developed the control firmware for a high power *B*-*H* measurement system using PWM. This is a specialized system in that it provides high power and high frequency stimulus for the evaluation of full-scale magnetic components. The basic experimental setup of this system involves the magnetic core under test, a full-bridge switch network, and control circuit. The switch network is controlled by a complex programmable logic device (CPLD) which, in turn, is controlled by a microcontroller. The microcontroller is responsible for relaying operational commands to the CPLD from the user and transmitting status information back to the user. I formulated the control algorithm and implemented it in both the CPLD and microcontroller. Additionally, I developed the user interface that sets test parameters and displays collected data. This control system not only enables the user to simulate important aspects of SMPS waveforms (e.g., different duty cycles, various switching frequencies, continuous-fixed mode operation), but also provides more accurate *B*-*H* loop measurements and core loss characteristics.

I wish to acknowledge the mentorship of Robert Wood.

Concealed Target Detection Using Augmented Reality with Synchronous Impulse Reconstruction (SIRE) Radar

Saponaro, Philip

The Synchronous Impulse Reconstruction (SIRE) forward-looking radar, developed by the U.S. Army Research Laboratory (ARL), can detect concealed targets like improvised explosive devices (IEDs) using ultra-wideband synthetic aperture technology. The SIRE radar has been mounted on a Ford Expedition and combined with other sensors, including a pan/tilt/zoom camera, to test its capabilities of concealed target detection in a realistic environment. Augmented Reality (AR) can be used to coalesce the SIRE radar image with the live camera stream into one view, which provides the user with information that is quicker to access and easier to understand than each separated. In this paper, we present an AR system that uses a global positioning system (GPS) and inertial measurement unit (IMU) to overlay a SIRE radar image onto a live video stream. We also developed a powerful, but easy-to-use graphical user interface (GUI) to allow the user to control the pan/tilt/zoom of the camera and change the sensitivity of the displayed radar image. The system also automatically detects regions of high intensity, automatically marks them, and warns the user if the vehicle is close to the detected target.

I wish to acknowledge the mentorship of Kenneth Ranney.

X-ray Analysis of the Dwell Mechanism in a Cover/Buffer Study for Encapsulated Ceramic Armor

Sceski, Blaise

Perfect armor requires a material that is hard and light—hard enough to stop an incoming projectile, but light enough to be used on vehicles or personnel without slowing them down. Ceramic armor possesses both of these qualities. However, further adjustments can be made to optimize the armor's performance. Total interface defeat is the capability of armor to defeat an incoming projectile on the armor surface. The projectile "dwells" on the surface instead of penetrating it, spewing the projectile material radially away from the impact point. The conditions under which dwelling occurs, however, are uncertain. Recent studies have demonstrated the existence of total interface defeat using confined ceramic targets with a simple cover plate. In order to study the mechanisms behind these results, x-rays of the penetrator/target interaction are captured directly after impact. The x-ray pulsars are optimized for the penetrator/target interaction region, and the x-ray images are enhanced in order to differentiate between the projectile and cover plate materials. The thickness of the cover plate is varied so as to determine a value that yields optimal dwell. They are recovered post-mortem, cross-sectioned, and x-rayed for radial and lateral micro-fractures.

I wish to acknowledge the mentorship of Carl Krauthauser

Flight Control of Micro Aerial Vehicles (MAVs)

Schneider, Kathryn

Flight control of micro-aerial vehicles (MAVs) is challenging due to the size of small-scale robotics platforms that puts size, weight, and power limitations on on-board sensors, as well as data processing algorithms, that can be implemented on the platforms. We will focus on computing optic flow in order to control a MAV using small vision chips, as opposed to a complex camera system, in order to cut down on the size and weight of sensors, as well as the processing power needed. We propose using an externally developed and produced vision sensor by Centeye to develop an algorithm for computing optic flow, from existing algorithms tailored to the sensor, to be used for the control of a quadrotor. Such efforts will benefit the various MAV research thrusts by providing a successful optic flow sensor and data processing algorithm that can be shared and applied to other robotic platforms in order to aid with other research.

I wish to acknowledge the mentorship of Will Nothwang.

Target Modeling for the Ground Mobile Branch (GMB)

Schulz, Matthew M.

This paper documents and explains the experiences and knowledge I have accrued through my work at the Army Research Laboratory (ARL) while assigned to the Ground Mobile Branch (GMB) of the Survivability/Lethality Analysis Directorate (SLAD). This Branch is tasked with the role of providing modeling and simulation support through the ballistic analysis of current and future vehicular systems. This role has traditionally been accomplished using three-dimensional (3-D) BRL computer-aided design (CAD) target geometries and the MUVES vulnerability model. SLAD provides analysis results that impact vehicle evaluation and assessment, which can lead to modifications. These modifications ultimately increase the survivability of a particular system. I was assigned to SLAD's Target Modeling Team (TMT) and directly supported the development of target geometries. To achieve this, I participated in the vehicle measurement process using modern metrology equipment, produced component-level target geometries through a variety of CAD packages, and aided the geometry conversion process through part reconstruction and part facetization. This report details my efforts and the insights I have gained while serving as a target modeler for the GMB.

I wish to acknowledge the mentorship of Scott Hornung.

On the Validity of Isotropic Eddy Viscosity Turbulence Models for Nanosecond Pulsed Plasma Flow Control Applications

Shaler, Kelsey

The use of nanosecond-pulsed dielectric barrier discharge (NS-DBD) plasma actuators on airfoils to delay the onset of stall is being investigated; therefore, models that properly account for the shear layer instability mechanics by which the flow responds to the plasma discharge are under development. Previous modeling efforts suggest that the commonly employed isotropic eddy viscosity turbulence assumption, i.e., Boussinesq's hypothesis, may significantly impact the spanwise vorticity development, thought to be the critical mechanism by which separated flows respond to NS-DBD actuation. In this work, the validity of isotropic eddy viscosity models is analyzed for separated flow control cases modeling NS-DBD actuation. The significance of eddy viscosity anisotropy is quantified by calculating the alignment angle between the Reynolds stress anisotropy tensor and the mean rate-of-strain strain tensor, both of which are obtained from Unsteady Reynolds Averaged Simulations (URANS). Since the alignment angle is proportional to the level of anisotropy, the Boussinesq-type turbulence models are expected to be less valid for higher values of the alignment angle. Quantitative results are calculated throughout the domain for various time instances in order to obtain flow visualization results for the development of the alignment angle as the flow responds to the NS-DBD actuation.

I wish to acknowledge the mentorship of Scott Hornung.

Deletion of the Phosphoketolase Gene from *Clostridium acetobutylicum*

Shankar, Jaishri

Clostridium acetobutylicum is involved in fermentation, which results in the production of organic solvents, specifically, acetone, butanol, and ethanol (ABE fermentation). Butanol has been identified as a promising gasoline alternative. *C. acetobutylicum* can produce these solvents by metabolizing various pentoses through two major pathways: the pentose-phosphate pathway and the phosphoketolase pathway. The phosphoketolase pathway, encoded by the gene CAC1343, is induced in the presence of arabinose, a pentose sugar, resulting in the formation of more oxidized products as compared to metabolism via the pentose-phosphate pathway. Induction of the phosphoketolase pathway results in decreased butyrate yields, ultimately decreasing butanol production. The purpose of this study is to delete the CAC1343 pathway using a *Clostridium* gene knockout system. Based on previous metabolism studies, when the phosphoketolase pathway is deleted, *C. acetobutylicum* growth in the presence of arabinose should induce only the pentose-phosphate pathway, resulting in increased production of butyrate and, eventually, butanol.

I wish to acknowledge the mentorship of Christian Sund and Matthew Servinsky.

Energetic Guest Materials in Metal-organic Frameworks

Sharma, Shaan

Improvements in the accuracy and control of a smart weapon can be achieved by tailoring the magnitude of explosion necessary to neutralize a target. Metal organic frameworks (MOFs), a hybrid organic-inorganic crystalline coordination polymer, offer potential for energetic material storage and controlled release. MOFs have been shown to have high thermal stability, which, if lent to an energetic guest material, would enhance control over an explosive charge. To this end, this work focuses on the adsorption of complex molecules into MOFs, analogous to possible energetic materials. Three MOF materials, Al(l,4-benzenedicarboxylate) (BDC), Zn2(BDC)2(4,4'-bipyridine) (BIPY), and Zn2(2,6-naphthalene-dicarboxylate)2(N,N-di(4-pyridyl)-1,4,5,8-naphthalenetetracarboxydiimide) (NDC and DPNI, respectively), are used in the following experimentation due to their unique qualities: Al(BDC) for the "breathing" mechanism of its pores and Zn2(BDC)2(BIPY) and Zn2(NDC)2(DPNI) for their strong- structured multi-ligand coordination. The synthetic molecule 4,4'-[1,4-phenylenebis(methylidynenitrilo)]bisbenzenethiol (PMNBT) was selected as a guest material not only because of its complex structure mimicking that of an energetic material, but because previous work indicates that it also exhibits useful properties for microscale electronics. Physical experimentation and grand canonical Monte Carlo simulation were used to observe the adsorption process of PMNBT into these MOF materials for the purpose of controlling the release of energetic materials.

I wish to acknowledge the mentorship of Govind Mallick.

Real-Time Alpha Burst Detection Using a Single Electroencephalography (EEG) Channel

Silversmith, Daniel

Driver fatigue is a major factor in 15-20% of fatal traffic accidents. Using electroencephalography (EEG) recordings provides a useful tool to assess drowsiness and prevent fatigue-related accidents. Many drowsiness assessment algorithms measure the relative power of frequency bands over time. However, there is substantial evidence supporting the correlation of alpha bursts (narrowband alpha power density increases lasting 500 ms to several seconds) with drowsiness. Alpha burst detection promises to be a more robust and targeted approach for drowsiness assessment. The aim of this paper is to describe an algorithm for the automatic detection of alpha bursts that can be implemented in real-time using a single EEG channel.

I wish to acknowledge the mentorship of Will Nothwang.

Modulating Music Based on Electroencephalography (EEG) Measures

Slayback, David

This project focused on creating a system capable of reading and processing electroencephalography (EEG) signals, and then using this data to alter music. Multiple evaluations of the system will be performed to ensure that the abilities of the system can be used fully. The system consists of an Emotiv Epoc EEG system, a pipeline using EmotivEEG Toolbox and MATLAB, an analysis script based on EEGLAB functions, a MATLAB graphical user interface (GUI) to take Karolinska fatigue tests, and scripts to scramble and run playlists automatically from Windows Media Player. Further, the system will be used to test the hypothesis that high energy music can help to reduce fatigue.

I wish to acknowledge the mentorship of Brent Lance.

Autonomous Self-righting in Three Dimensions on Planar Ground

Smith, Daniel C.

Robots are increasingly being used for combat, urban search-and-rescue, and reconnaissance missions. During these operations, robots may be subject to falling over, risking mission success, asset recovery, and timeliness of completion. Successfully controlling robots to right themselves can be a difficult, time- consuming task, and this can negate many of the advantages that robots would otherwise provide. This paper details offline planning software to assist in autonomous self-righting, using a quasi-static, graph- based approach that we previously developed . Using an offline model, the software iterates through all possible joint-configurations of the robot, determining in which orientations the robot can rest for any given configuration. A graph is constructed from this information, grouping similar orientations. The robot can then use this graph online to determine a series of motions to right itself from any configuration and orientation. For this work, we have extended our previous framework to three dimensions while reducing the required conformation space map by one dimension, improving computation time. This was done by investigating faces and facial yaw, rather than the traditional yaw, pitch, and roll of the robot. In addition, our approach and software is robust to avoiding self-collision. Both the software and the approach are validated by testing them in simulation and on a modular, custom robot.

I wish to acknowledge the mentorship of Chad C. Kessens

Analyzing Power Line Events, Techniques, and Results

Smith, Darren

It is well known that electric power lines generate significant electric fields due to the electric voltages on the lines and significant magnetic fields due to the load currents. In 2009, the U.S. Army Research Laboratory (ARL) analyzed data from experiments to generate relative phasor plots, a new way of displaying multiple dimensions of relevant data for load events and histories. In 2010, development began for a new tool for analyzing load events in real time, called the Live Animated Multi Phasor (LAMP). LAMP computes and displays phasors for streaming live power-line data. It then uses these phasors to detect and identify events. In 2011–2012, processing techniques from LAMP were expanded upon and used over months of continuously recorded data from several different experiments. For example, event maps show patterns of on-off activity in a common time base. These maps are a new way of displaying a large number of events, allowing an analyst to quickly gain a high-level understanding of the data. Applications include energy conservation and condition-based maintenance. This paper describes the tools and provides some sample results that have been obtained using the tools.

I wish to acknowledge the mentorship of David Hull.

Angle of Arrival Calculation During Signal Saturation

Sridhar, Ananth

The U. S. Army Research Laboratory (ARL) has developed a tetrahedral microphone array system for acoustic based target detection and localization. Given a set of time-domain data, one array can estimate differential time of arrival (TOA) and angle of arrival (AOA) information. Use of multiple arrays allows for triangulation. However, limitations in acoustic detection hardware, such as microphone range, analog to digital conversion (ADC) saturation, and uncontrollable testing conditions can produce incoherent signals. One form of these signals, saturation events, can occur due to close proximity to a transient event. This renders target localization difficult with standard algorithms. The goal of this project is to develop an algorithm to detect transient events that saturate an acoustic system. This is done in two parts: detection and window selection. The algorithm analyzes data from the microphone array, returning timestamps that correspond to multi-channel saturation. Results have shown that detection rates have improved from 20% to 100% for an ARL tetrahedral microphone array located approximately 60 m from the launch position of a large-caliber, indirect fire weapons system. Based on the data, an appropriate window selection algorithm is used to extract a time window suitable for AOA computation.

I wish to acknowledge the mentorship of Geoffrey Goldman.

Dynamic Mechanical Analysis Data Management through Efficient Automated Data Transfer and Analysis

Steele, Garrett

Materials informatics and data mining computational tools are now moving towards the practicality needed for drawing accurate correlations between complex high loading rate response and simpler quasi-static properties. However, the proposed approach of associating experimental testing results through a materials informatics scheme requires large data sets with high pedigree and integrity. The objective of this project was to acquire data from sample testing and enhance the search ability of these results on to a centralized database. Dynamic Mechanical Analysis (DMA) was used to characterize epoxy samples. The DMA was used to not only obtain the glass transition temperature of the sample, but to further analyze the data to obtain the Prony Series Coefficients for the sample. The DMA also provides the following data for the structures and thermal properties: elastic modulus (or storage modulus), viscous modulus (or loss modulus), and damping coefficient (tan delta) as a function of temperature and frequency. Challenges arising from data collection and analysis automation were encountered.

I wish to acknowledge the mentorship of Wendy E. Kosik Chaney.

SEED Small Unit Force Protection Mechanical Design

Stephey, Tyler

In keeping with the U.S. Army Research Laboratory's mission statement, this design project is meant to aid Soldiers by ensuring that they have the most accurate and easily obtainable information needed for the completion of their task. The project is part of an initiative to give small units of deployed Soldiers more real-time situational awareness by providing a tactical sensor apparatus that can be deployed via a telescopic mast, mounted to a transport vehicle. Specifically, the work presented here is primarily focused on the mechanical design and computer-aided modeling of the apparatus, with the goal of optimizing in-the-field functionality, and sensor performance and protection.

I wish to acknowledge the mentorship of Brian Mary.

Digital Three-dimensional (3-D) Modeling Educational Module

Stratford, Colin

The advent of digital three-dimensional (3-D) modeling software with highly intuitive user interfaces and low price points has, in the past 10 years, expanded the use of digital 3-D modeling beyond its traditional professional designer user base. The accessibility and availability of software such as Trimble SketchUp (previously Google SketchUp) has made using such software a realistic option for middle- to high-school educators seeking to demonstrate basic mathematical concepts using an engaging and stimulating medium. An educational module based on performing simple exercises with the SketchUp program has been designed with input from both students in the targeted age group (6^{th}–8^{th} grade) as well as interested educators. Age-appropriate mathematical concepts are demonstrated in introductory "tool" lessons, while later exercise "extensions" allow students to creatively respond to design challenges in a format where the decision-making initiative is placed on the students themselves. These later exercises are a realistic introduction to the types of design-problems faced by professional designers and seek to instill in students an enthusiasm for careers in scientific and engineering design-type professions. While a full-scale test of the module has yet to be undertaken, preliminary feedback suggests that a workable foundation for the exercise has been established.

I wish to acknowledge the mentorship of Stephen (Drew) Wilkerson.

Polysaccharide Gelled Ionic Liquids for Flexible Dye-sensitized Solar Cells

Sweeney, Charles

There has been an increasing need to extend the effective runtime of multifunctional robotic platforms in order to give them more practical battlefield applications. Therefore, robust power solutions, which may be incorporated into any structural system, need to be realized. Solar energy is an abundant renewable resource capable of meeting the power requirements for a wide range of robotic vehicles. Dye-sensitized solar cells (DSSCs) have recently become a competitive photovoltaic technology, due to their low manufacturing cost and relatively high efficiency, especially in ambient lighting conditions. However, the liquid electrolyte commonly employed in DSSCs limits the potential for flexible devices manufactured using reel-to-reel printing methods. Furthermore, these liquid electrolytes must be hermetically sealed in order to operate properly and prevent off gassing of volatile organic compounds. Herein, we present a study of non-volatile room temperature ionic liquid (RTIL) electrolytes based on the iodide/triiodide redox couple, gelled with common low molecular weight polysaccharides. The physical properties of the gel electrolytes are evaluated, and their resulting performance in flexible DSSCs is assessed.

I wish to acknowledge the mentorship of Mark Bundy.

Review of the Literature and an Evaluation of Training for Enterprise Resource Planning Systems

Sweeney, Holly

An Enterprise Resource Planning (ERP) system is software that is capable of supporting all functions of a business enterprise, including accounting, logistics, and material management. Implementing a new ERP system is an extensive process that involves proper training for users in order to ensure both a smooth transition to the new system and to promote employee acceptance of the system. This paper consists of a literature review on ERP systems, focusing on different training methods, as well as issues and critical success factors for implementing a new system. This paper discusses a MANPRINT evaluation of an ERP system recently implemented in the Army. A survey was administered to users to evaluate the effectiveness of the training. MANPRINT domains of Manpower, Personnel, and Human Factors Engineering were also investigated. Users of the system found that over-the-shoulder and follow-on training were effective, while computer-based and instructor-led training were ineffective at teaching the users how to complete their specific job tasks, and need improvement for future use. The evaluation will be used to develop a training model to improve user training of ERP systems. Improvements on ERP system usability were also identified.

I wish to acknowledge the mentorship of J. O. Grynovicki.

Extending High-performance Computing (HPC) Capacity and Capabilities to Low-power, Mobile Devices

Tade, Curtis

There are various projects that intend to provide the Soldier with an efficient way of performing heavily parallel computations from a mobile device, but many of these require an infrastructure of high-performance computing (HPC) machines. In situations where access to HPC machines is nonexistent and the only means for accomplishing resource-intensive computations are mobile devices, the solution is to use the processing power of each available device. To accommodate this solution, we suggest implementing a mobile message-passing interface that can be used by a wide range of comparable mobile devices. We use a Bluetooth ad-hoc network to establish a cluster of Android-based devices running computations in parallel. Using the low power radio transmissions of Bluetooth allows us to submit computational requests from one device to a dynamic mobile network of devices without deteriorating the limited power resources needed for processing. We present our experimental results through an Android application running on the low-power, reduced instruction set code (RISC)-based processors of PandaBoard single-board computers. We have established a Bluetooth ad-hoc network between multiple PandaBoards and will be running comprehensive tests to benchmark the capabilities of computing over a personal area network (PAN) of mobile devices.

I wish to acknowledge the mentorship of David Bruno.

The Effects of Computer-aided Translation Tools on Low-resource Language Document Production

Tanenbaum, Will

One feature of low-resources languages is the inconsistent use or sometimes even total absence of technical terms, jargon, nomenclature, etc. Dari and Pashto are two such languages. Due to the Army's strategic interest in Afghanistan, an enormous number of technical documents must be translated from English into one or both languages. Given the scarcity of fluent speakers of both an Afghan language and English who are also subject matter experts in a technical field, these experts' knowledge and time must be used as efficiently as possible. To this end, translators were provided the computer-aided translation (CAT) tool Omega-T, which assists its user via translation memories and a user-generated glossary. The effects of Omega-T's use were measured and compared to a similar translation effort made without a CAT tool. The results, as well as their implications, are analyzed and discussed in my paper.

I wish to acknowledge the mentorship of Stephen LaRocca.

Gamma Radiation Sensor Network Includes Spectroscopic Identification

Temples, Dylan

A network of compact, inexpensive gamma-radiation sensors composed of bismuth germanium oxide (BGO) scintillators and avalanche photodiodes has been developed to detect radiation levels above environmental background. This network was designed to run in Geiger mode (GM); however, by including a 128-position digital potentiometer, they can be used to collect and evaluate spectroscopic data. While running in spectroscopy mode (SM), the sensors have been configured to identify gamma lines in the energy range of 400 keV to 2.1 MeV. One limitation encountered in SM is increased dwell time per energy bin (120 total), which increases the total time required to achieve good statistics over the entire spectrum and reduces gamma-line resolution. While the line resolution of these sensors is 40% for ^{137}Cs at 661 keV compared to 7% in laboratory configurations using photomultiplier tubes (PMT), they are suitable for identifying the most prevalent of isotopes in early warning or cueing applications.

I wish to acknowledge the mentorship of Marc Litz.

Testing and Validating a Novel Method to Assess Muscle Fatigue via Surface Electromyography

Tenan, Matthew S.

Determination of dismounted Soldier muscular fatigue is of paramount importance to Army operations. The median frequency (MPF) of the surface electromyogram (EMG) is a reliable method of determining muscle fatigue in isometric conditions, but not dynamic movement. Recent research indicated that rectified frequency spectrum more accurately reflects the firing rates of the muscle fibers; therefore, the rectified median frequency (rMPF) may prove more valid for fatigue determination than MPF. This study tested the hypothesis that both MPF and rMPF would decrease throughout a fatiguing isometric exercise. This study tested 17 subjects during an isometric knee extension held at 25% maximal force production. MPF and rMPF were calculated at the start of exercise and at 10% intervals until task failure. Both MPF and rMPF were found to significantly decrease across the task ($p<0.05$). Further, while MPF and rMPF were shown to be significantly different from each other at each stage ($p<0.05$), the pattern of change across the isometric task was similar. Thus, this study demonstrates the potential utility of rMPF in determination of muscle fatigue. Future studies should investigate whether rMPF outperforms MPF as an indicator of muscular fatigue in dynamic tasks and can be used in operationally relevant tasks.

I wish to acknowledge the mentorship of Dr. Harrison P. Crowell.

Phosphorus and Aluminum-based Additives for High Voltage Lithium-ion Electrolytes

Tipton, Caroline

The goal of our research was to develop and test the performance of phosphorus- and aluminum-based additives in the electrolytes of high voltage lithium-ion batteries. Ideally, these batteries could operate with a cell voltage of 5 V; however, these high voltage conditions put a significant strain on the liquid electrolyte. The additives are meant to improve the high voltage stability of the electrolytes. When normal carbonate-based electrolytes decompose at potentials lower than 5 V, they form a solid electrolyte interphase (SEI) layer that is critical to the performance of the battery. The composition of the SEI layer can be altered by adding small amounts of reactive compounds to the electrolyte. We tested two different fluorinated alkyl phosphate as well as two aluminum-based derivatives as additives for our standard electrolyte. To test additive performance, we used an experimental 4.7-V $LiNi_{0.5}Mn_{1.5}O_4$ cathode as a test platform. To generate more commercially viable data, we also used a lower-voltage $LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$. We found that the higher-voltage cathodes performed better with phosphate-based additives, while the lower voltage cathodes performed better with aluminum-based additives. These results confirm that phosphorus- and aluminum-based additives have a positive effect on the performance of lithium-ion batteries.

I wish to acknowledge the mentorship of Dr. Arthur V. Cresce.

Computational Image Processing of Spark Shadowgraph Images

Tipton, John

An experiment was performed to determine whether image processing software can be used to replace the manual reading of spark shadowgraph images. The experiment consisted of developing three computer codes. The first code was developed to scan the Transonic Experimental Facility's (TEF) spark shadowgraph film from a flatbed scanner. It also integrated code previously developed to scan the Aerodynamic Experimental Facility's (AEF) spark shadowgraph film using the Vidar DiagnosticPro Advantage© scanner. A separate program allows the user to name the scanned shadowgraphs by station number and properly orient the images to be used by the image processing program; it was modified to read film produced from scanning the TEF film. The third program used image processing techniques from National Instrument's Vision Development Module© to extract relevant data from each image. The data collected from each image were processed to find the projectile's position and angular orientation at each station. This data were then used by the Aeroballistics Research Facility Data Analysis System (ARFDAS) to reproduce the projectile's flight path, from which the aerodynamic coefficients can be determined. The experiment is considered successful if this new method is both faster and more accurate than the current method for collecting data.

I wish to acknowledge the mentorship of Sidra Silton and Ilmars Celmins.

Carbon Nanotube Arrays and Graphene Sheets as Nanoenergetic Materials

Tozier, Dylan

Nanoenergetic materials have drawn significant interest due to their large energy and power densities. Current work in nanoporous energetic silicon films has demonstrated that nanoenergetic materials can have combustion propagation velocities on the order of 3000 m/s, films have been integrated on-chip, and can be used as sources of mechanical and electrical energy in conjunction with other microelectromechanical systems. Several other materials have potential as an on-chip nanoenergetic, most notably large surface area forms of carbon such as nanotube arrays and graphene sheets. Just as with the nanoporous silicon, we impregnate the large surface area carbon with a strong oxidizer, and with the application of heat, produce a strongly exothermic oxidation. We aim to characterize this oxidation with respect to the resulting gas output, energy output, and combustion propagation velocity for use as a nanoenergetic material. We hope that carbon nanotube arrays and graphene sheets may be integrated on-chip similarly to nanoporous energetic silicon.

I wish to acknowledge the mentorship of Luke Currano.

Accelerating Image Feature Detection Using a Field-programmable Gate Array (FPGA)

Trimeloni, Thomas

The U.S. Army Research Laboratory is researching vision-based guidance systems for precision munitions in order to decrease target location error and reduce reliance on global positioning systems (GPS). These systems rely on computationally intensive feature detection algorithms to recognize and track objects of interest. The challenge is to find a compact, low-power, low-cost implementation suitable for the constraints of affordable munitions while providing the computing power necessary for feature detection in a highly dynamic environment. One solution is to use a field-programmable gate array (FPGA), which offers significant computing power in a cheap and compact package. The reprogrammable nature of these devices allows performance increases to be achieved by exploiting the parallelism within an algorithm. This work explores the effectiveness of using an FPGA to implement the Speeded Up Robust Feature (SURF) algorithm. Specific sections of the SURF algorithm are analyzed and profiled to determine their suitability for FPGA implementation. These sections are implemented and simulated in MATLAB's Simulink environment to provide an empirical estimate of performance, size, and power requirements.

I wish to acknowledge the mentorship of Michael L. Don.

Investigation of Förster Resonance Energy Transfer (FRET) Coupling via Electrical Characterization of Protein, Polymer, and Quantum Dot Based Thin Films

Tumlin, Travis

Layer by layer (LBL) assembly has long been used as a method to deposit thin films with molecular-level control on their morphology and functionality. More recently, this technique has been applied to research areas such as biosensors and nanoscale electronics. LBL deposition is made possible through electrostatic self-assembly between oppositely charged substances. In this work, we investigate the Förster Resonance Energy Transfer (FRET) coupling between bacteriorhodopsin (bR) and cadmium selenide (CdSe)/zinc sulfide (ZnS) quantum dot (QD) thin films assembled using the LBL technique. FRET describes the transfer of energy between two chromophores. The efficiency of this energy transfer is inversely proportional to the sixth power of the distance between these two chromophores, thus making the energy efficiency extremely sensitive to separation distances. In the case at hand, bR and QDs act as the two chromophores. FRET coupling is characterized by investigating the energy output of the bR/QD films. A polymer spacer with a known separation distance is used to separate the bR/QD films. Once the spacing between the films has been achieved, the change in electrical output with and without the polymer spacer is investigated.

I wish to acknowledge the mentorship of Mark Griep.

Permittivity Measurements and Statistical Analysis of the Portable Ring-Resonator Permittivity Measurement System (PRRPMS)

Turner, Eric James

The Portable Ring-Resonator Permittivity Measurement System (PRRPMS) has been developed at the U.S. Army Research Laboratory (ARL) to measure the permittivity of various dielectrics in-situ with minimal disturbance. Permittivity has a direct effect on buried targets' signatures and determines the depth at which they can be detected. The transmission, reflection, and absorption of a radiated electromagnetic wave are affected by the soil's permittivity. The in-situ measurements of permittivity are imperative to accurately model the behavior of radar pulses in a test environment. Thus, measuring permittivity has a great significance in developing ARL's Ultra-Wide Band (UWB) Synchronous Impulse Reconstruction (SIRE) Ground Penetrating Radar (GPR). This paper provides an in-depth statistical analysis, characterizing measurement accuracy and precision to ultimately quantify the performance of the PRRPMS in a controlled environment. These results are then compared to measurements that have been recorded in-situ at Yuma Proving Ground (YPG), Arizona. The aforementioned analysis will determine the usefulness of the PRRPMS in calculating the loss induced by penetration through soil.

I wish to acknowledge the mentorship of Kelly Sherbondy.

Enhancing Android Static Analysis through Market Basket Analysis

Venturino, Eric

Mobile malware has an increasing presence on commercial mobile computing platforms. Between January 2011 and January 2012, malicious Android applications increased from 139 to 3,069 and malicious families increased from 10 to 37. The Army is deploying Android smart phones and tablets on the battlefield, which may be a target for malware. In our research, we attempt to improve static analysis techniques to determine if an Android application is malicious. Previous works have focused on permission combinations. We expand the search to a larger number of permission and intent combinations to find reliable indicators of potentially malicious activity. We separately mined 306 malicious and 1059 benign Android applications for information that pertained to native code, extra application files, permissions, and intent filter information. Market basket analysis, an analysis to find co-occurrence relationships, was used to examine indicator relationships. The results of market basket analysis from the malicious and benign data sets were compared. We then generated patterns of indicators that detected a high percentage of malware samples with a low false-positive rate. The results show that static analysis can be an effective tool to detect Android malware.

I wish to acknowledge the mentorship of William Glodek.

Novel Power Combining Techniques for Gallium Arsenide (GaAs) Power Amplifier Chips: Improved Efficiency and Power Performance at Ka-Band

Waiyaki, Caroline

Current communication systems are using traveling wave tube amplifiers (TWTAs) that are bulky and costly, and require high power supplies. Advances on solid-state device technologies with benefits such as low supply voltage, graceful degradation, low development cost, and high power densities, have made solid state power amplifiers (SSPAs) very attractive as TWTA replacements. Gallium arsenide (GaAs) device technology has demonstrated maturity at microwave frequencies for many decades. In order to achieve high power levels at these microwave frequencies, planar power combining is frequently used for SSPA chip designs. In this work, a single-ended GaAs PA has been designed with 18.4-dBm output power (P_{out}) at a 1-dB compression point, 8.4-dB power gain, and 39.8% power added efficiency (PAE) at 26.5 GHz using Triquint's 0.13-µm D pseudomorphic high electron mobility transistor (pHEMT) process. In addition, a novel two-way planar power combiner/divider that incorporates harmonic suppression, Wei-Chi, has been designed and implemented within the SSPA combining two of the above PA designs with measured results of 21.88-dBm P_{out}, 7.59-dB power gain, and >40% PAE. The measured S-parameter and power results for the two designs show great agreement with simulated results. The Wei-Chi combiner/divider shows a marked improvement in SSPA PA power and efficiency performance.

I wish to acknowledge the mentorship of Edward Viveiros.

Automatic Pan-Tilt-Zoom Camera Calibration for Saliency Driven Scene Exploration

Warnell, Garrett

In pursuit of a saliency driven scene exploration method, I consider the implementation of a method for *self* or *auto calibration* of a pan-tilt-zoom (PTZ) camera. This problem is well studied in the literature, but a readily accessible implementation of the proposed methods does not appear to exist. Adopting this as a goal, I have developed software to interface with an Axis P5522-E PTZ camera and performed some of the most prevalent existing self-calibration techniques. Implemented methods use a set of images collected over various PTZ parameters to estimate the calibration matrices intrinsic to each view. Point correspondences are determined using Scale Invariant Feature Transform (SIFT) features, and inter-image projective transformations are robustly estimated using a nonlinear least squares technique. Assuming that no camera translation occurs during the acquisition process, the camera calibration matrix can be estimated from the parameters of these transformations. I discuss the theory behind these methods and the practical steps involved in computing the calibration parameter estimates. I also discuss the relationship to the overarching problem of saliency driven scene exploration and show results that demonstrate the utility of automatic calibration in that context.

I wish to acknowledge the mentorship of Douglas Summers-Stay.

Mode I Fracture Response of Epoxy with a "Tinked" Crack Tip Profile

Weerasooriya, Tishan

To determine the Mode I facture behavior for epoxy EPON 825 bis(aminocyclohexyl) methane (PACM) at different loading rates, a unique four-point bend-specimen was developed. Different variations of this specimen geometry were previously developed and used in investigating Mode I fracture behavior of other materials such as epoxies and adhesive/aluminum interfacial bonds. In this study, fracture behavior of EPON 825 PACM was investigated under three loading rates: quasi-static, intermediate, and high. Quasi-static and intermediate rate experiments were conducted using an Instron hydraulic test machine, and high rate experiments were done using a Split-Hopkinson Pressure Bar (SHPB). For all the experiments, a high-speed digital camera was used to capture when the crack initiation occurs and follow the propagation of the crack. Crack tips were created by "tinking" method from a single impact of a sharp razor blade. In addition, the results of the fracture response from "tinked" cracked tips were compared to previous work that focused on a saw-notched crack tip profile. Ultra-high speed digital image correlation (UHS-DIC) was used as a moving virtual crack detection gage (MVCDG) on all the epoxy fracture specimens, which provided an accurate technique to determine crack initiation and progress through the specimen and measure crack opening displacement (COD).

I wish to acknowledge the mentorship of Paul Moy.

Development of Semi-autonomous Control System of a Novel Hovercraft

Wenger, Kevin

Semi-autonomous vehicles serve an important purpose in military application, as they allow user-control with the advantage of incorporating sensors and feedback to create a more robust control system. The main focus of this study is to gain directional control and steering that will provide for reasonable forward propulsion. The hovercraft platform will serve as a reconnaissance vehicle, as well as a way of testing the feasibility of integrating compliant structures in low-friction devices. This paper outlines the development of a joystick-controlled semi-autonomous control system for a novel hovercraft platform. Features of this system include pulse width modulation (PWM), speed control of thrust fans, wireless communication with a joystick connected laptop, gyroscopic balancing, and control of a servo-actuated compliant arm mechanism. This paper will provide a system overview, and a description of hardware and software and plans for future research.

I wish to acknowledge the mentorship of Asha Hall.

High Dynamic Range Nonlinear Measurement Using Analog Cancellation

Wetherington, Josh

A nonlinear measurement system has been implemented using an analog canceller to improve characterization of weakly nonlinear systems. While the target or device under test may often exhibit highly nonlinear behavior in wired (conducted) situations, the coupling of electromagnetic energy into the target from a remote source can be very low and any distortion or intermodulation products generated even lower still. The implemented system uses high gain power amplifiers to drive a moderately high-power two-tone probing signal. The high-power signal is expected to generate low-level intermodulation distortion measurable in the return signal after interaction with the target. To extend the dynamic range of the receiver for very low-level nonlinear detection in the presence of the high-power stimulus signal, feedforward analog cancellation is used to remove the large interfering tones. The analog canceller is automated using digitally controlled vector modulators with an efficient cancellation algorithm and allows for measurement of nonlinear distortion very close in frequency to the cancelled stimulus tones, normally suppressed in filter-based systems, over a large bandwidth.

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The Effect of Sintering on the Structure and Density of Lithium Lanthanum Titanate ($Li_{0.29}La_{0.59}TiO_3$) Targets for Pulsed Laser Deposition

White, Joseph

There is considerable interest in lithium lanthanum titanate ($Li_{3x}La_{(2/3-x)}TiO_3$ or LLTO) as a solid-state electrolyte in lithium-air batteries due to its high potential for ionic conductivity. However, since the ionic conductivity of LLTO is limited by the grain boundaries, oriented thin films of LLTO provide a possible solution to increase the ionic conductivity. Pulsed laser deposition (PLD) is a film deposition technique that can produce highly oriented thin films matching the stoichiometry of the target. To prepare targets for PLD, calculated stoichiometric quantities of lithium carbonate ($Li_2(CO_3)$), lanthanum oxide (LaO_3), and titanium oxide (TiO_2) were mixed in ethanol for 1 h. The resulting powder was calcined for 1 h at 1100 °C, pressed into pellets using a cold isostatic press, and sintered for 4–9 h from 1100–1300°C. The density of the pellets was measured, and the targets and thin films were characterized using x-ray diffraction, optical microscopy, and scanning electron microscopy. The sintering procedure closely affected the density of the target, with higher temperatures and longer sintering times allowing more densification. Once the ceramic LLTO targets were optimized, the pulsed laser deposition parameters, including substrate temperature and oxygen pressure were studied with the goal of producing high-quality, grain-oriented LLTO thin films for Li-air batteries.

I wish to acknowledge the mentorship of Claire Brennan.

Lakeshore Hall System for Hall Characterization

Wijewarnasuriya, Dineth

The goal of this project is to set up a temperature variable Lakeshore Hall system for Hall characterization purposes. Hall measurements are used for measuring the conductivity, doping, and carrier type of semiconductor materials, which are very important attributes and impact device performance. The primary goal is to develop a control/data acquisition interface for the current source, voltage meter, magnet, temperature controller, and other electronic equipment associated with the Hall system using Labview software. Once the variable temperature control system is set up and tested, measurements will be made on various semiconductor materials as a function of temperature. This will be a new capability available to the team and will allow for more advanced material characterization.

I wish to acknowledge the mentorship of Matthew Chin.

Using Electro-spray Ionization to Investigate the Magnesium-ion (Mg^{2+}) Solvation Sheath

Wikner, Emily

While lithium (Li)-ion batteries have become the state-of-the-art energy storage device, researchers have targeted magnesium (Mg)-ion battery as the next generation rechargeable chemistry. Not only does the Mg-ion have a higher volumetric energy density than that of Li, but it also is more widely available with a high abundance in the Earth's crust. It has been shown that the Li^+ solvation sheath structure plays a critical role in determining cell kinetics; however, researchers know almost nothing about how the Mg^{2+} cation is solvated in non-aqueous electrolytes. In this work, bis(trifluoromethane sulfonyl)imide (HTFSI) acid was produced via the cation exchange of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) and reacted with magnesium hydroxide ($Mg(OH)_2$) to form $Mg(TFSI)_2$ salt. Extraction and recrystallization techniques were used to purify $Mg(TFSI)_2$. Upon purification, 0.5M $Mg(TFSI)_2$ electrolyte solutions were prepared by dissolving with various ratio concentrations of non-aqueous electrolytes, ethylene carbonate (EC)/ethyl methyl carbonate (EMC), ranging from 0:100 to 90:10. Electro-spray ionization (ESI) mass spectroscopy will be performed to determine the structure of the Mg^{2+} solvation sheath. Quantitative analysis will also be conducted to map the statistical distribution of cyclic and acyclic carbonate molecules inside the Mg^{2+} solvation sheath. This will lead to a better understanding of the charging/discharging kinetics of future Mg-ion batteries.

I wish to acknowledge the mentorship of Dr. Kang Xu.

Simplifying Simplicial Complexes Via Q-Analysis Coreduction

Wilkerson, Adam

In this paper, I describe a novel method for reducing the dimension and complexity of simplicial complexes using the approach of Q-Analysis in social science. I convey how to make precise a particular measure, called *eccentricity*, of a simplex's contribution to its parent complex's homology. I exploit the point of view that eccentricity is more than a mere heuristic to eliminate those simplices that offer no contribution to the homology of their parent complex, thus replacing the original complex with a quasi-isomorphic complex that has with far fewer vertices and simplices. This is achieved through a convenient duality of the complex with its *conjugate complex*, made explicit here. I prove that eliminating these less-relevant simplices doesn't affect the location of the shortest paths around holes in the original complex, thus making hole-location and homology-computation algorithms much more efficient. Finally, I demonstrate, using the publication dataset of the U.S. Army Research Laboratory's Communications & Networks Collaborative Technology Alliance, that this algorithm can be used to reduce a 10-dimensional simplicial complex to a far simpler five-dimensional complex while maintaining the overall topological structure of the social network.

I wish to acknowledge the mentorship of Terrence Moore.

Micro-electromechanical System (MEMS) Automated Testing Platform

Wills, Ronald Kent

Thorough characterization of micro-electromechanical system (MEMS), silicon-based semiconductors, and novel III-V based semiconductors through radio frequency (RF) and DC testing requires a multitude of user actions. These user actions can introduce human error, which can lead to non-repeatable testing conditions and a loss of valuable time for the tester. Currently, the automated testing platform operating in the "RF IC and MEMs Characterization Labs" serves to alleviate these issues. However, much of the code is legacy C/C++ making it hard to maintain and update. Every addition of a new testing procedure currently requires a separate development effort and verification. The automated testing platform will be rewritten in C# and use SQL Server as a data manager to increase the productivity and efficiency of component testing, as well as provide a file base to effortlessly add new tests. In turn, this will enhance the laboratory's capabilities in terms of internal device characterization as well as external device evaluation. The platform will be validated through testing mechanical logic memory elements developed through the Defense Advanced Research Projects Agency (DARPA) nano-electromechincal system (NEMS) program, evaluating their yield, lifetime, data retention, and switching speeds.

I wish to acknowledge the mentorship of Robert Proie.

Organization of Activity Monitor Accelerometer Data Using MATLAB

Wojciechowski, Matthew

Activity monitors—devices commonly used to measure accelerations of a Soldier's body during various tasks—were calibrated in a recent study. The data from multiple experimental trials will all be output in a single file because the monitors only measure acceleration data from when they are switched on to when they are switched off. Because the sampling frequency used is 100 Hz, and because there were many experimental trials, very large, unorganized amounts of data were generated. The activity monitors also note the time of day at which they begin recording. Start times for each experimental trial were recorded manually during the study. A script was written in MATLAB to use the data file and an Excel spreadsheet with the trial timeframes to separate the data recorded from the accelerometers into different Excel spreadsheets for each trial. This script, with modification, can be used for any future applications of organizing activity monitor acceleration data.

I wish to acknowledge the mentorship of William Howard Harper.

Characterization of PiezoMEMS Resonators

Wolfson, Samuel

Piezoelectric, lead zirconate titanate (PZT) microelectromechanical systems (MEMS) resonators have many potential applications as filters, transformers, and oscillators. The use of contour and other vibrational modes, where the frequency setting dimensions are largely determined by the in-plane lithographically defined dimensions, enables MEMS resonators to address the chief limitation of current technologies. Existing PZT resonators show great potential but can be improved by design techniques that can achieve low insertion loss with fewer spurious modes. To this end, characterization of PZT MEMS resonator designs on wafers with 2μm, 4μm, and 10μm of device layer silicon was performed in order to test various methods of reaching these goals. The data will guide the design of future resonators by demonstrating the effectiveness of using additional tethers to suppress spurious modes and placing multiple devices in parallel to improve insertion loss.

I wish to acknowledge the mentorship of Jeffrey Pulskamp.

Training Classifiers in Deep Networks for Face Detection

Won, Stephen

The U.S. Army relies on reliable surveillance to increase the Soldier's knowledge of his or her surroundings. Face detection can be used with facial recognition to differentiate allies in an environment with multiple humans. The current method for face detection is the Viola-Jones object detection algorithm, which uses a cascade of weak classifiers to ensure reliable, real-time detection of faces. However, faces under sharp illumination and rotation cannot be detected if the classifier is not trained to recognize them. We demonstrate that a number of effective face-detecting classifiers can be trained using deep networks in MATLAB with the GPUmat package. The classifiers are trained using publicly available face databases. After training, the performance of the classifiers is evaluated using publicly available databases and acquired imagery in the laboratory. We will show that these classifiers can perform comparatively to the cascade of weak classifiers in the OpenCV package with the Viola-Jones framework on a common image set with frontal faces. In addition, we attempt to demonstrate that classifiers trained from deep networks can be more robust than those in the Viola-Jones framework to detect faces with illumination and rotation variations.

I wish to acknowledge the mentorship of Susan Young.

High-speed Supercapacitors

Xu, Alice

Supercapacitors have the potential to be a high power energy source while retaining a long cycle life. High-speed performance requires low electronic resistance and high ionic conductance. My experiment focuses on increasing ionic conductance through engineering the electrode porosity. Controlling the configuration of the pores is important for facilitating the diffusion of electrolyte ions to the electrode surface. Larger, less convoluted pores will speed up ion diffusion and thus capacitor performance. I use solution ionic strength to manipulate the graphene sheets into mesoporous microspheres, which have larger pores than restacked graphene sheets. I also experiment with electro deposition methods to form macroporous electrodes and work on optimizing these methods used to create high powered supercapacitors. Scanning electron microscope (SEM) imaging, cyclic voltametry, and electrochemical impedance spectra are then used to determine the structure and power performance of the electrodes developed.

I wish to acknowledge the mentorship of Matthew Ervin.

Analysis of Cospectral Data from the HLCS Program

Xu, Kevin

Using the newly updated Huynh, Li, Chang, and Sridhar (HLCS) program, we can now obtain a plethora of knowledge from the Joint Union 2003 (JU2003) data set. The JU2003 data set consists of the elevation of the measuring instrument, the wind velocity, which is decompiled into three vector directions u, v, and w, and the temperature (T). The data in JU2003 were decomposed by HLCS into various spectra, which were exported out of the HLCS as images and Excel spreadsheet files. This paper focuses on the analysis of the exported data of the HLCS program, concentrating on the analysis of the cospectra of certain quantities: u, w, and T. Using a new batch of programs, we are able to see that some relationships exhibited in certain quantities in the HLCS program show up in the analysis of the cospectra. Certain cospectra can give us important quantities such as heat flow and vertical stress. Therefore, we can use cospectral data to analyze the relationship of such properties over height or atmospheric stability.

I wish to acknowledge the mentorship of Sam Chang.

Coherent Combining and Stimulated Brillouin Scattering (SBS) Suppression in Erbium Fiber Amplifiers

Yang, Zhi Yi

To reach the high power lasers the military is interested in, we use two methods: coherent beam combining and suppression of stimulated Brillouin scattering. High power lasers are becoming increasingly more complex and expensive to build. Using optical phase lock loops to coherently combine several beams, it is possible to scale up the power with current technology. By coherently combining several lower power lasers, one can create a high power laser with lower cost and complexity. Stimulated Brillouin scattering is a nonlinear optical effect in which high intensity beams create a backwards propagating wave that can become self reinforcing and siphon energy from the forward propagating wave. This backward beam can also become intense enough to damage the laser source. A linearly chirped laser can disrupt the self reinforcing cycle and therefore limit this effect. In this experiment, a chirped diode laser seeds two 10-W erbium (Er) fiber amplifiers, which are coherently combined by an optical phase-locked loop. We are able to show beam combination with a path length difference of ~1 m while maintaining 75% combining efficiency.

I wish to acknowledge the mentorship of Jeffrey White.

Observed Short Channel Effects when Scaling Down Micro-transistors

Zhu, Emmeline

The transistor is a fundamental component in integrated microcircuits. Semiconductor devices are used as both an amplifier and a switch at high speeds, ergo their high utility. “Moore’s Law,” a trend formulated by the co-founder of Intel, Gordon E. Moore, expects that the density of transistors in a single microchip will double every 18 months. The miniaturization of transistor gate length has so far been in agreement with Moore’s Law; however, as transistors approach atomic-sized dimensions, output impedance performance decreases, which plays a significant factor in a transistor’s gain. On the other hand, frequency response increases as channel length scales down, which could be leveraged to overcome the decreased gain. The purpose of this project is to measure the output impedance and –3 dB frequency across an array of technology nodes. Simulations will be created using Cadence, a software specifically exploited for integrated circuit (IC) design. Produced data are compared using the numerical computing environment Matlab. The following results should reveal the correlation between a transistor’s gate length and its overall effectiveness. This study aims to assist in overcoming the ongoing challenge to design faster transistor technologies without losing significant efficiency.

I wish to acknowledge the mentorship of Dr. James Wilson.

Real-time Electric-field-based Projectile Detection: Simulation and Implementation

Zhu, Jack

Triboelectric (frictional) and combustion processes impart electrostatic charge on projectiles as they are fired. Electric-field (E-field) distortions due to moving charged bullets have been previously detected and quantified on E-field sensing hardware. There is an interest in using these signals to help detect and track projectiles in counter-sniper and projectile ranging systems. Algorithms and sensing platforms have been devised to track charged projectiles, however, there is currently no interface to effectively evaluate these sensing configurations. This project details the development and application of software to simulate real-time charged projectile detection and analysis. A program was written to simulate E-field signatures from bullet trajectories at different charges, velocities, miss distances, and angles. The program also allows the user to simulate signatures due to different E-field sensors, as well as model noise characteristics of the sensors and the environment. The software serves as a test platform for different sensor placement geometries and filtering, detection, and calibration algorithms. Future applications of the software platform, as well as development plans, are discussed.

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